Technology Review

DECEMBER 1961 *Edited at Massachusetts Institute of Technology*

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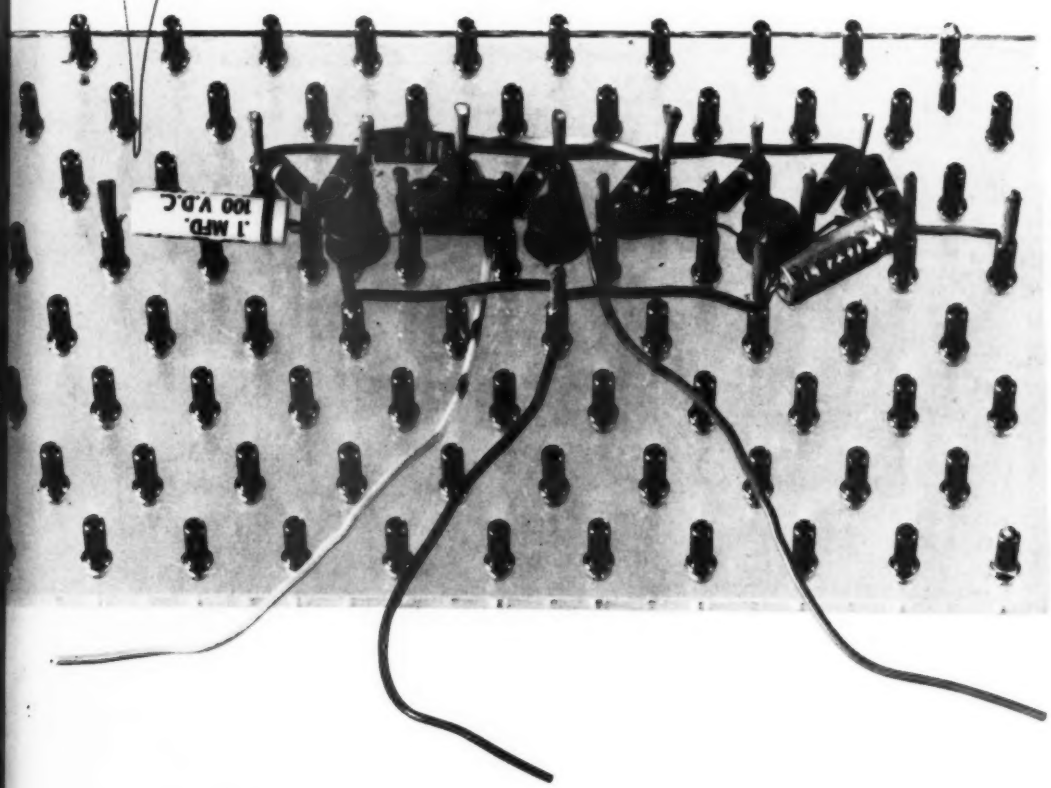

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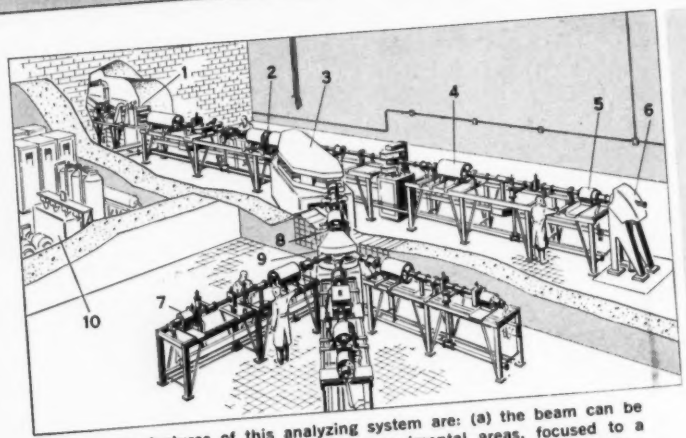
High Voltage Engineering Corporation . . .

"CHARGED PARTICLES"



Typical high power electron beam analyzing and deflecting system for 10 to 80-Mev, 30 kw linac

1. Linac
2. Positron Target
3. Deflecting Magnet System and Energy-Defining Slits
4. Focusing Lens
5. Neutron Target
6. Terminating Magnet
7. Targets (3)
8. Monoenergetic Gamma Target
9. Switching Magnet
10. Equipment Room

The main features of this analyzing system are: (a) the beam can be delivered to any of three different experimental areas, focused to a small spot or spread out over a large area to facilitate target cooling; (b) net energy dispersion of the beam after deflection is negligible. This means that maximum beam of the desired energy is available because particles of varying energies move along the same center line into target regions; (c) in the deflecting magnet system there is a large energy dispersion at a collimator, which selects the required energy spectrum with a precision of 0.1 per cent or better; (d) the part of the electron beam discarded at this collimator or elsewhere in the system produces x-rays, the major portion of which are directed away from experimental areas; (e) the system can be converted to handle positrons produced in a shower target close to the entrance of the deflecting magnet system.

High Power Linacs

In a recent discussion of *High Energy Linacs*, we indicated that the power of the new accelerators, plus better energy resolution opens up intriguing possibilities for the experimental physicist. One of these possibilities involves production of a monoenergetic gamma-ray beam, with adjustable energy, heretofore just a dream.

Positron annihilation in flight in a thin target produces such a gamma-ray beam. The linac electron beam is used to produce positrons in a wide energy spectrum in a shower target. These particles are energy-analyzed in a deflecting magnet before they impinge upon the annihilation target. Energy selection of the gamma rays is accomplished by varying the magnetic field of the deflecting magnet. The conversion factor is small, so it is essential to have an intense electron beam. It is not essential, however, to have a high degree of beam-energy homogeneity.

An experiment in which beam-energy homogeneity is important is the spectroscopic study of inelastically-scattered electrons from nuclei. Magnetic spectrometers for this kind of experiment can be built with a resolution of better than 0.1 per cent, and the electron beam must be analyzed to this accuracy before it impinges upon the scattering target.

Hot Electron Beams

The high accuracy and power called for in these experiments requires considerable beam-handling ingenuity. The problems may be illustrated: A typical high-energy linac will put 45 kw of high-energy electrons on a one-half centimeter square — this equals 180 kw/cm², enough to vaporize any known material in a few seconds. To make such a system fail-safe requires precisely-protected beam slits and electron scattering devices, and specially cooled vacuum chambers, in addition to the analyzing and collimating equipment. The situation is complicated by an x-ray background which prohibits use of organic materials for coil insulation and vacuum gasketing.

The beam analyzing and deflecting system is an increasingly complex and important part of the linac experimental facility. An inadequate system will greatly reduce the accelerator's research utility. Fortunately, High Voltage Engineering has had years of experience designing and building extremely accurate, magnetic analyzing systems to guaranteed specifications.

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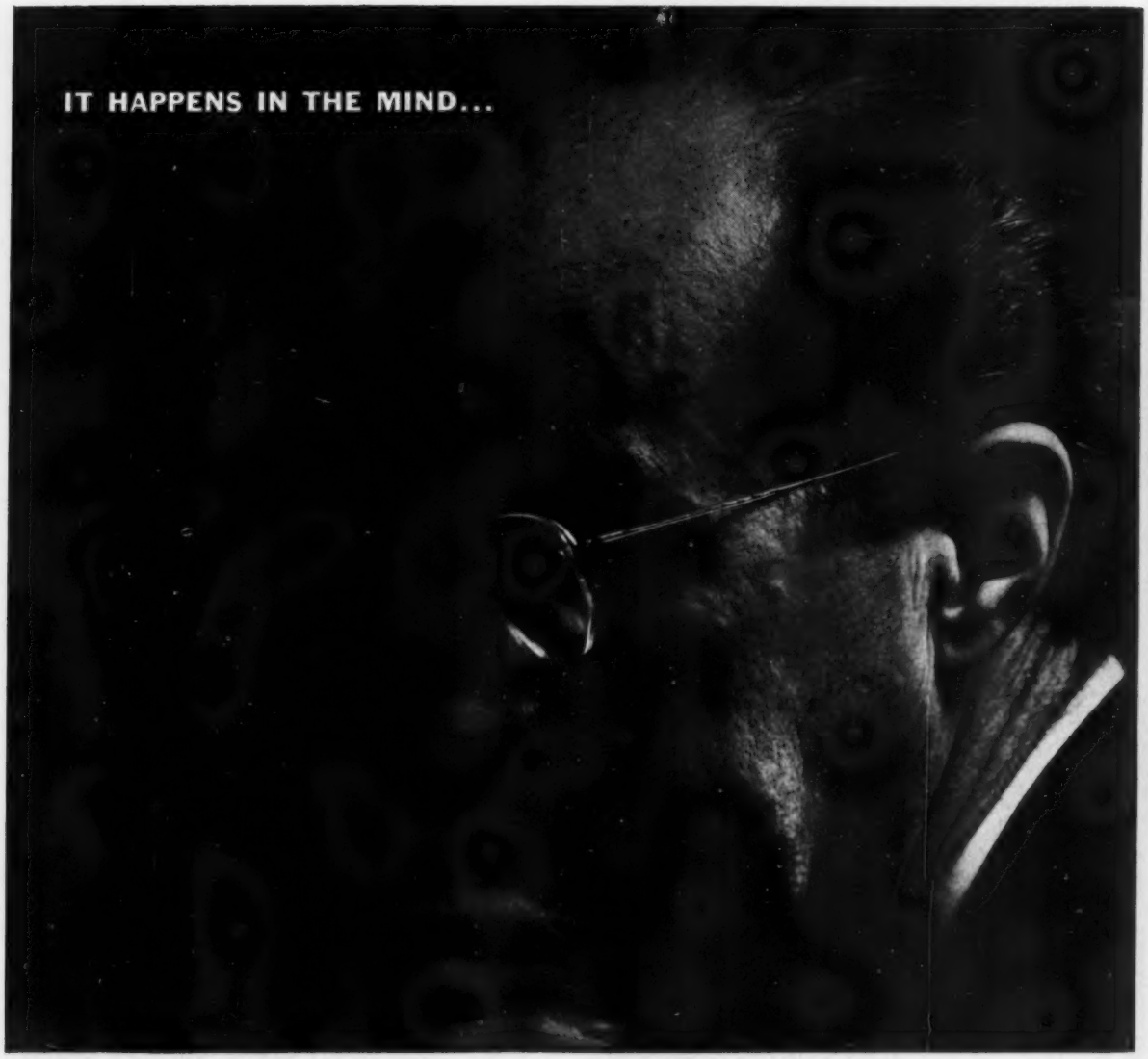

...It is essentially a thing of the mind for it works through concepts, symbols and relationships... it helps man to analyze and synthesize the complex phenomena of the universe and himself... it works in many ways to advance electrical communications:

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BELL TELEPHONE SYSTEM

Technology Review

Reg. U.S. Pat. Off.

Volume 64, Number 2 *Edited at the Massachusetts Institute of Technology* *December, 1961*

BUILDING plans of many kinds are being considered at M.I.T. Above is a proposed extension to the Dorrance Building for work in life sciences. A new model of the Earth Sciences building is shown on page 15, and there are photos of the new Harvard-M.I.T. Electron Accelerator's impressive quarters on page 29.

Feedback

Coverage of M.I.T.

FROM ARTHUR J. WEINBERGER, '41:

I'd like to compliment you and the staff of The Review for a fine job over the years. I hope you will not be unduly influenced by the "Letter to the Editor" last year, which urged less reporting of activities about M.I.T., and more articles with "intellectual stimulation." For many of us The Review is our only continuing contact with M.I.T., and I would hate to see reporting of M.I.T. activities curtailed.
Stamford, Conn.

The new center of alumni population had 286 people in 1950, and 301 in 1960, official U.S. Census reports show (see page 33 of this issue of The Review).

EDITOR: Volta Torrey; BUSINESS MANAGER: R. T. Jope, '28; CIRCULATION MANAGER: D. P. Severance, '38; EDITORIAL ASSOCIATES: J. J. Rowlands, Francis E. Wylie, John I. Mattill; EDITORIAL STAFF: Ruth King, Joan B. Brassert, Roberta A. Clark; BUSINESS STAFF: Madeline R. McCormick, Patricia A. Fletcher; PUBLISHER: H. E. Lobdell, '17.

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Individuals Noteworthy

Charles L. Miller, '51 Heads Department Of Civil Engineering

DEAN Gordon S. Brown, '31, of the School of Engineering, has announced the appointment of Professor Charles L. Miller, '51, as Head of the Department of Civil Engineering.

In announcing the appointment, Dean Brown said: "Civil Engineering at M.I.T. has been undergoing rapid change and development. Extensive faculty studies have brought the educational and research objectives of the department into clear focus and are providing the basis for a new era in civil engineering activity at the Institute. Professor Miller has played an important role in evolving the new program and plans. As head of the department, he is charged with implementing the objectives and goals of a dynamic program in civil engineering."

Professor Miller's professional contributions have been in information systems as applied to civil engineering. He has made noteworthy contributions in the areas of digital computer methods and photogrammetric systems, having evolved the Digital Terrain Model System of location analysis and the COGO System for civil engineering communications with electronic computers. In addition to having developed the Photogrammetry Laboratory, he was responsible for the formation of the new Civil Engineering Systems Laboratory for interdisciplinary research on a wide range of civil engineering problems.

Born in Tampa, Fla., in 1929, Professor Miller received both his bachelor's and master's degrees from the Institute. For four years prior to his appointment to the Faculty in 1955, he was with the firm of Michael Baker, Jr., Inc., Consulting Engineers.

Professor and Mrs. Miller have three children and make their home in Lexington, Mass.

Samuel Herrick

The Hunsaker Professor

THIS YEAR'S Jerome Clarke Hunsaker Visiting Professor at M.I.T. is Samuel Herrick, on leave of absence from the University of California at Los Angeles, where he is professor of astronomy. Dr. Herrick is an authority on celestial mechanics and astrodynamics, and especially interested in trajectory analysis, guidance problems, and the reduction of satellite and related data.

He is giving a graduate course in astrodynamics at the Institute, participating in seminars and research, and will give the Minta Martin lecture next spring. This lecture is sponsored annually by the Department of Aeronautics and Astronautics and the Boston section of the Institute of Aerospace Sciences.

Dr. Herrick studied at Williams College and the University of California at Berkeley. He founded the Institute of Navigation, and was its president in 1952-1953. He is now a director of the American Rocket Society.

Professor Wiener Injured

A FALL on the stairs in Building 1 sent Institute Professor Norbert Wiener to the Massachusetts General Hospital this fall. He recovered rapidly, however, and resumed preparations for further travels abroad.

Faculty Activities

GEORGE R. HARRISON, Dean of the School of Science at M.I.T., and Alan T. Waterman, Director of the National Science Foundation, were nominated to be president-elect of the American Association for the Advancement of Science this year. Results of the election will be announced at the Denver meeting of the AAAS this month. Participants in its Denver program will include Professors *Arthur R. von Hippel, Jerome Y. Lettvin,* and *Giorgio de Santillana.*

The American Institute of Electrical Engineers presented the David Sarnoff Award in Electronics this year to *Charles H. Townes,* Provost of M.I.T. . . . Other recently announced honors included the American Chemical Society's Award in inorganic chemistry, sponsored by Texas Instruments Incorporated, to Professor *F. Albert Cotton;* the same society's award in the chemistry of milk, sponsored by the Borden Company Foundation, to Professor *David F. Waugh;* and the Kendall Company Award in colloid chemistry, to Emeritus Professor *George Scatchard.*

John T. Howard, '35, Head of the M.I.T. Department of City and Regional Planning, discussed "Airports: Access and Community Impact" at a Hartford, Conn., symposium on air transportation in November. . . . Provost *Charles H. Townes* discussed "Masers and Other Solid State Devices" at a recent meeting of the Corporate Associates of the American Institute of Physics, and M.I.T. was one of 16 institutions given silver certificates in recognition of a quarter century of continuous support of its services in the field.

Dr. Stratton's Assistant

DOUGLAS A. EAST, '55, has joined the office of M.I.T. President Julius A. Stratton, '23, as Administrative Assistant. He received the Goodwin Medal for outstanding teaching in June, 1960, and is now a candidate for the doctor's degree.

James G. Kelso has assumed new responsibilities as Assistant to the Chairman of the Corporation and Special Assistant in the Development Office. He will be concerned with community relations and Second Century Fund work.

(Continued on page 6)

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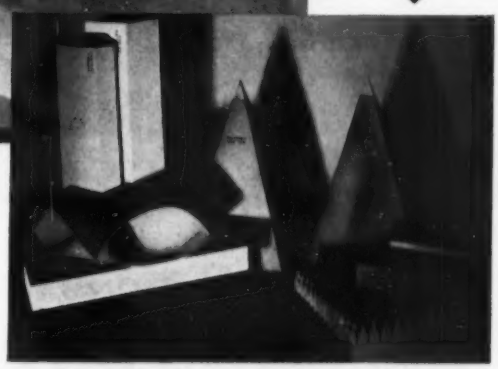

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Individuals Noteworthy

(Continued from page 4)

Honors to Alumni

MEDALISTS and recent recipients of other distinctions include:

John T. Norton, '18, the Plansee Plaque, for contributions to powder metallurgy, at the 4th International Plansee Seminar, Reutte, Austria . . . *Crawford H. Greenewalt, '22,* the 1962 John Fritz Medal, by United Engineering Trustees, Inc. . . . *Oscar H. Horovitz, '22,* named a Fellow, by the Photographic Society of America;

Harold E. Edgerton, '27, named an Honorary Fellow, by the Institute of Amateur Cinematographers . . . *R. B. Woodward, '36,* the first Pius XI Gold Medal, for "achievements in chemical synthesis," by Pope John XXIII . . . *Howard K. Schachman, '39,* the American Chemical Society Award in Chemical Instrumentation, sponsored by E. H. Sargent & Company . . . *Milton M. Platt, '42,* the first Fiber Society Award for "distinguished achievement in basic or applied fiber science," by the Fiber Society.

(Continued on page 10)

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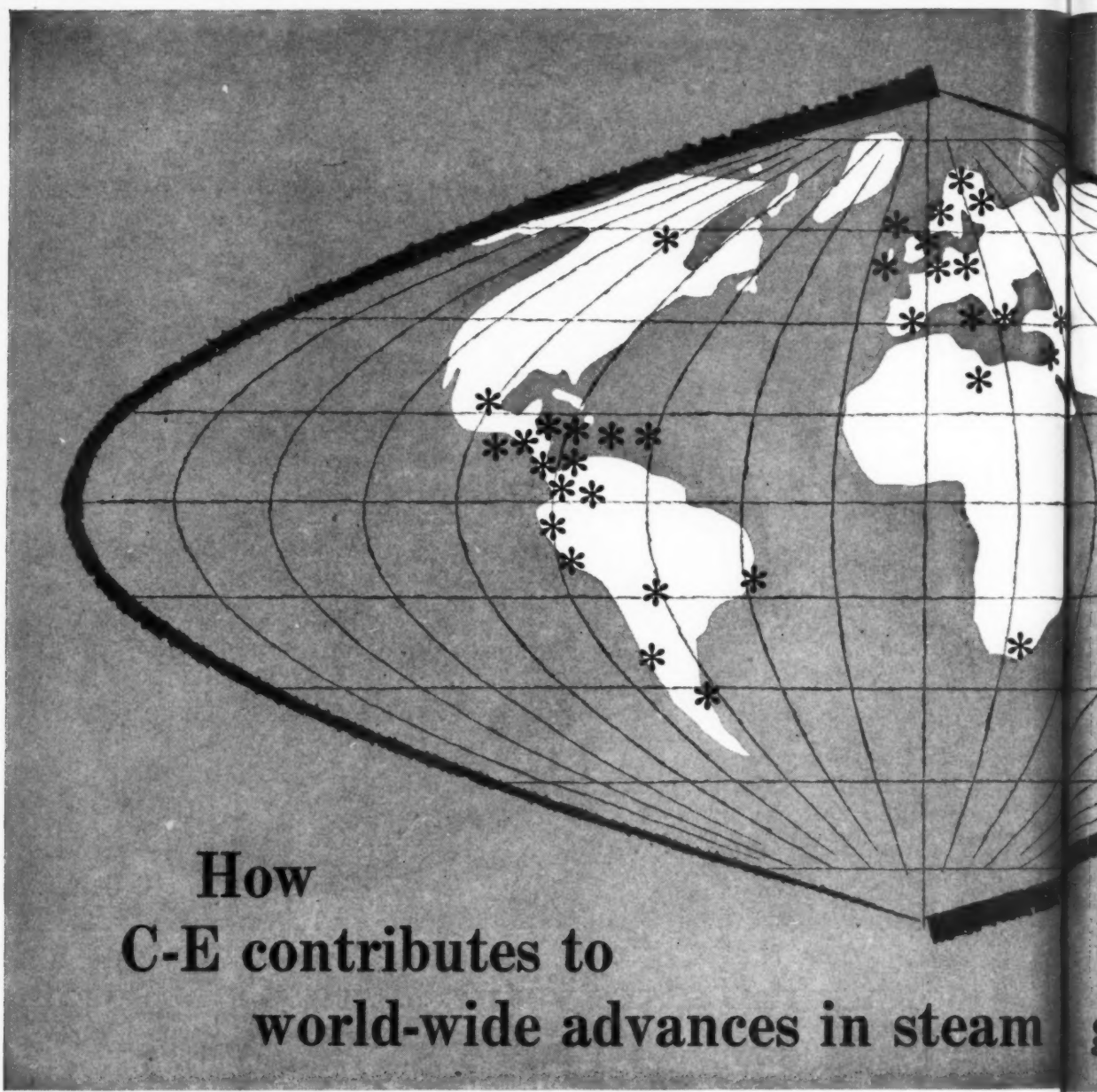

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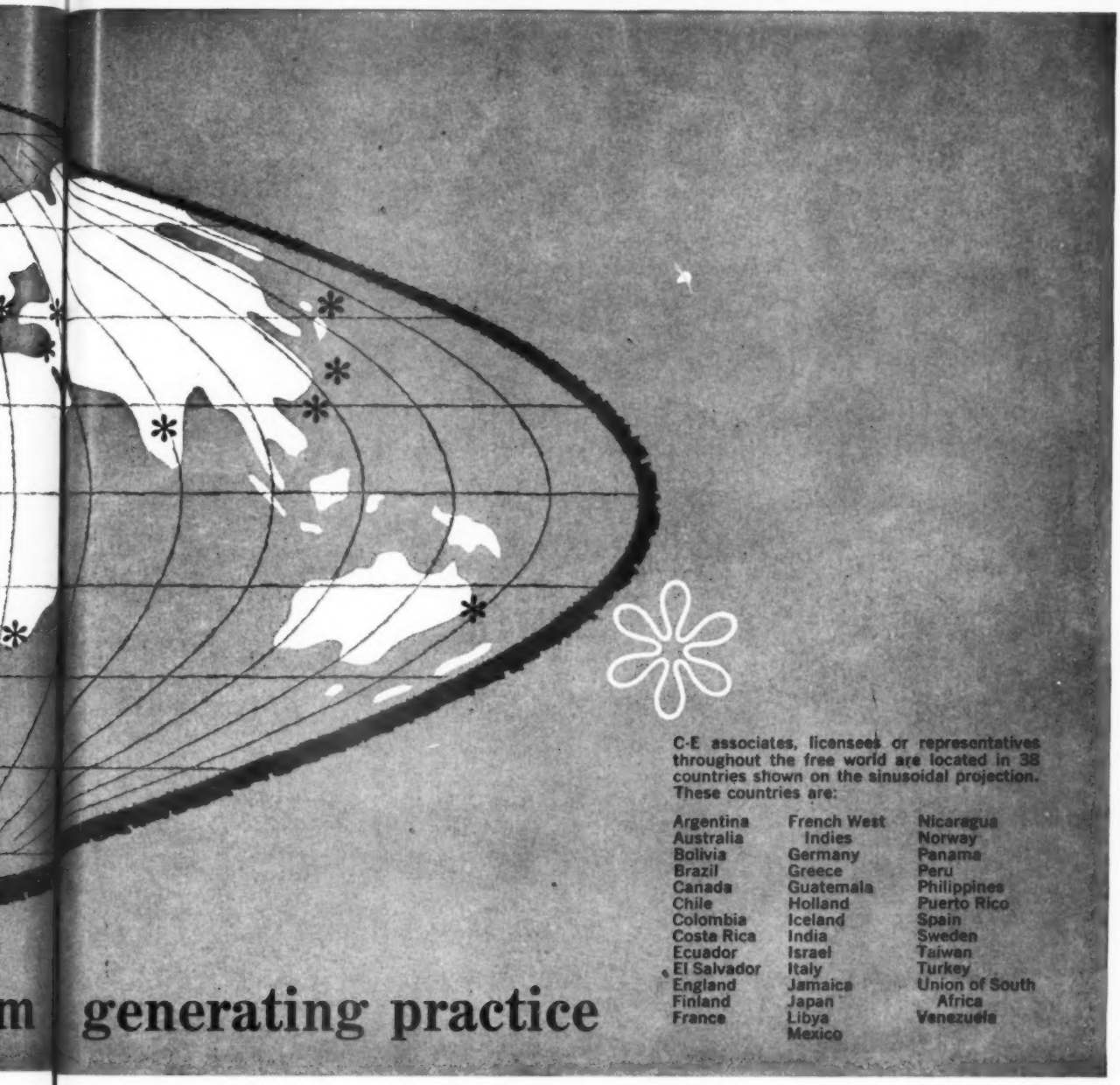

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Ecuador	Italy	Taiwan
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Individuals Noteworthy

(Continued from page 6)

Visiting the Middle East

EUGENE R. CHAMBERLAIN, associate adviser to foreign students at M.I.T., left this fall for a six-week tour of seven countries in the Middle East to study admissions programs of schools there, the work of agencies engaged in international educational exchanges, and to learn first-hand how schools in those countries interpret U.S. procedures.

M.I.T. has the second largest percentage of foreign students among U.S. schools, and Mr. Chamberlain hoped to visit many parents of students and Alumni as well as visit schools in Iran, Kuwait, Iraq, Lebanon, Syria, Egypt, and Turkey.

Lectures Abroad

PROFESSOR Paul A. Samuelson of M.I.T. was chosen to give the Lord Stamp Memorial Lecture at the University of London in November. Lord Stamp was a distinguished businessman who was a victim of the bombing in the last war. Professor Samuelson's topic was "Problems of the American Economy."

Next May, Professor Samuelson will go to Stockholm to give the Wicksell lectures.

(Continued on page 38)

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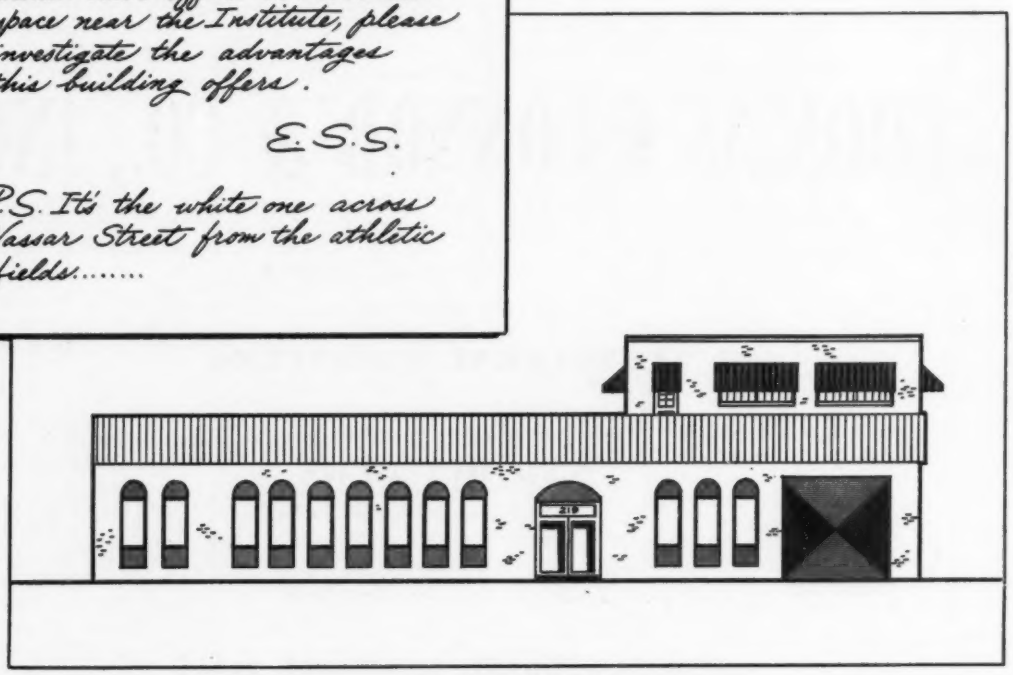
E.S.S.

P.S. It's the white one across Vassar Street from the athletic fields.....



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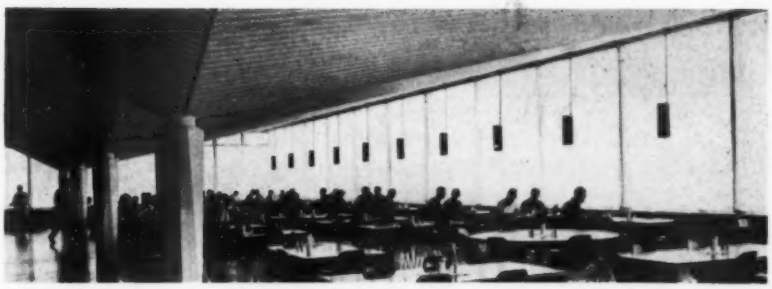


The New Materials Center

WORK has begun, President Julius A. Stratton, '23, disclosed in his annual report this fall, on the architectural design of a home for the M.I.T. Center for Materials Science and Engineering. A $3,275,000 contract to further research in materials was concluded with the Advanced Research Projects Agency last June, and organization of the center has proceeded since then under the direction of Institute Professor John C. Slater and Professors Peter Elias, '44, and Nicholas J. Grant, '44. The Materials Center will be an interdepartmental laboratory in which Faculty members and students from many departments of both the School of Science and the School of Engineering will participate.

Research and teaching in the field of materials science and engineering will continue to occupy considerable space in the present buildings and will expand into the 150,000 square feet of new space to be made available by the new building. Plans are being made now to move certain research programs in the Departments of Physics, Chemistry, Metallurgy, and Electrical Engineering into the new quarters.

The new five-story building will be located immediately north of the great dome, will join to Building 10 and extend west to Building 7 and east to Building 12. Its construction will be a first step in the redevelopment of the North Campus in keeping with the original concepts of Welles Bosworth, '89, the architect of the main buildings erected in 1916.

The new building will also provide a headquarters for the administrative services for the center and will permit the consolidation of central facilities for crystal growth, analytical chemistry, electron microscopy, shops and stockrooms for research in materials. Elwood W. Schafer, '32, has returned to the Institute to handle these administrative matters for the Materials Center.

Many surrounding facilities, including an IBM 709 computer now being installed on the fourth floor of Building 10 to provide increased computer time for scientific problems, will contribute to this centralization of activities in materials science and engineering.

"There is perhaps no other new field that affects directly the interests of so many departments," President Stratton noted, "and all have co-operated magnificently in planning new curricula and new teaching laboratories in this rapidly developing area."

A Bank Supports Education

THE New England Merchants National Bank established a broad new policy of financial support for educational institutions by making a $25,000 grant to M.I.T. this fall.

"Business and industry in Massachusetts have special reason to support education and, in particular, M.I.T.," said Richard P. Chapman, the bank's President. "The economy of the state is undergoing a period of important adjustment brought on by the rapid technological and economic change. To a greater extent than ever before, Massachusetts must develop its technological resources in order to accelerate industrial growth. M.I.T. has had a major part in contributing the ideas, the scientists and engineers, and the momentum for the emergence of research-based industry. Banks are playing a constructive role in providing essential capital for new-growth industries. We can also help quicken economic growth by supporting education and research."

In acknowledging the grant, James R. Killian, Jr., '26, Chairman of the M.I.T. Corporation, said: "I wish to express gratitude, not only for M.I.T. but also on behalf of all private educational institutions, which depend increasingly upon the business community for financial aid. In view of the enormous demands now being made on colleges and schools, we must look to new sources of support to augment the older and traditional forms of individual benefactions. The generous assistance of business and industry can be a vital factor in maintaining the independence and strength of our private educational institutions."

WTBS Is on the Air

THE M.I.T. students' educational FM radio station, WTBS, went on the air this fall with a three-hour program of recordings that included *John Brown's Body* and *Pagliacci*. Station Manager Lewis M. Norton, '62, says the station's high-fidelity capabilities permit a radiated audio frequency response of 50 to 15,000 cycles per second with a maximum distortion of 1 per cent. Quality technical specifications were met by student engineers, who built much of the station's equipment.

PICTURED ABOVE is the interior of the new Burton House dining room. The Alumni Fund helped provide this and other improvements in housing for M.I.T. men.

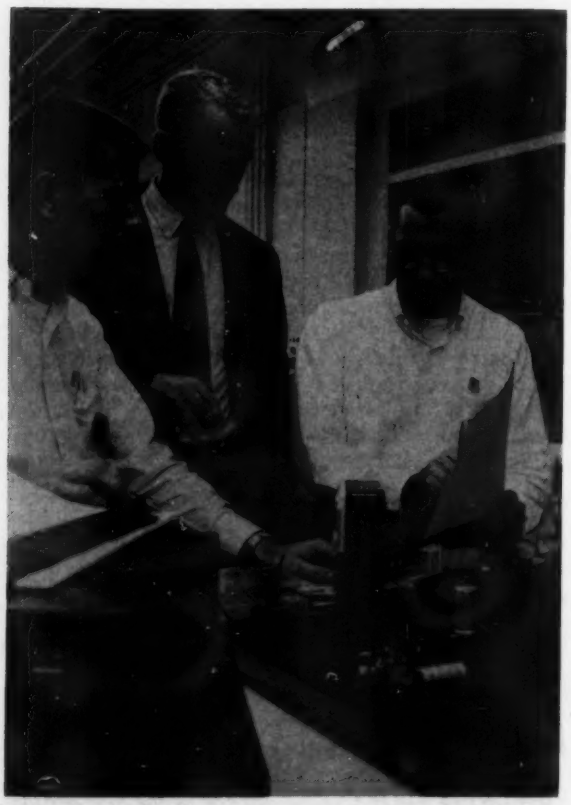
Learning With Toothpicks

THE KEY ELEMENT in the take-home laboratory now being used by M.I.T. students of electrical engineering is a toothpick. The whole "laboratory" is a box no bigger than some of the reference books that students often consult. Most of its components—resistors, capacitors, transistors, and diodes—are about the size of kernels of corn, and students assemble them into circuits on a pocket-sized plugboard. Toothpicks are used to hold tiny wires against the metal sides of tiny sockets. (The resilience of the wood used in toothpicks makes them ideal wedges.)

With a box of parts, a transformer, rectifier, meter, and a handful of toothpicks, a student now can perform many experiments in his room. He often must still go to a central laboratory for an oscilloscope, signal generator, or some other device, the way he goes to a library for reference material, but much of his work can be done at whatever pace and hour he chooses.

Richard D. Thornton, '54, Associate Professor of Electrical Engineering, developed the new kits with the help of William F. Schreiber, Associate Professor of Electrical Engineering, and others, as part of the current intensive effort to improve undergraduate education in engineering at M.I.T. The kits were created to encourage thoughtful experimenting by making it convenient.

The kits also have proven to be economical. A complete unit can be assembled for less than $50, and most of the parts can be used time after time.



Richard D. Thornton, '54 (center), checks work being done with take-home equipment by electrical engineering students.

The Treasurer's Report

LAST YEAR'S changes in the Institute's financial affairs were summarized as follows in the report of Joseph J. Snyder, '44, Vice-president and Treasurer, to the Corporation this fall:

	1960-61	1959-60	Change
Academic operations	$ 29,889,000	$ 25,468,000	+$ 4,421,000
Departmental and interdepartmental research	20,314,000	17,763,000	+ 2,551,000
Lincoln Laboratory, Instrumentation Laboratory, and Operations Evaluation Group	56,996,000	48,787,000	+ 8,209,000
Total funds	122,657,000	114,625,000	+ 8,032,000
Plant assets	49,269,000	44,814,000	+ 4,455,000
Gifts and grants	14,584,000	17,355,000	— 2,771,000
Investments			
Market value	191,252,000	173,574,000	+ 17,678,000
Book value	121,706,000	113,043,000	+ 8,663,000

Operations in 1960-1961 and the previous year were compared in this table:

Revenues and funds	**1960-61**	**1959-60**
Tuition and other income	$ 9,054,000	$ 7,889,000
Investment income	1,832,000	2,223,000
Gifts and other receipts	8,270,000	6,081,000
Allowances for indirect expenses	8,802,000	7,432,000
Dining and student housing	1,931,000	1,843,000
Total	$29,889,000	$25,468,000
Expenses		
Academic	$12,299,000	$10,670,000
General and administration	10,915,000	9,017,000
Plant operations	4,744,000	3,938,000
Dining and student housing	1,931,000	1,843,000
Total	$29,889,000	$25,468,000

Funds sharing in the income from the general investments earned 6.29 per cent on the average book value compared to 6.36 per cent last year.

A Minister and Engineer

RANDALL L. GIBSON, '51, both works in the Instrumentation Laboratory at M.I.T. and serves the First Unitarian Church of Woburn, Mass., as its minister. He attended the Harvard Divinity School after receiving his M.I.T. degree in Electrical Engineering and is now pursuing two careers.

In the laboratory he works on components for inertial guidance systems used in missiles. "I would prefer," he recently told The Boston *Herald*, "that nobody had to do any kind of work that was connected with the possibility of war, but the fact of the matter is that we're in a jam. We've been backed into a corner and need both a positive defense posture and greater concentration on the means of achieving understanding."

His church has about 100 parishioners and an edifice built in 1870. The building is being modernized and from its pulpit the Reverend Gibson tries to speak "to the needs of the present."

The Big WGBH Fire

THE studios of WGBH in the Hennessey building across Massachusetts Avenue from the main M.I.T. buildings were destroyed October 15 by one of the biggest fires in the Institute's history. The early morning, three-alarm fire, generally ascribed to defective wiring, damaged the three-story building so greatly that it probably will not be restored.

WGBH, which is Boston's famed educational FM and TV station, was able to resume broadcasting quickly with the facilities of the Television Center of the Catholic Archdiocese and the help of commercial broadcasters and many friends. A drive for funds to replace the station's lost equipment and enable it to continue its services was launched immediately.

The drug store, restaurant, and other businesses which occupied the first floor of the building have been greatly missed. Institute students who cracked the books there have been driven elsewhere, the Tranquillity Club which met faithfully in Walton's for years has not yet agreed on a new meeting place, and the coffee machines within walking distance of Institute offices and classrooms have been overworked.

The Orbiting Dipole Experiment

LINCOLN LABORATORY was continuing the radar search, as this issue of The Review went to press, for the millions of tiny dipole fibers sent aloft from Point Arguello, Calif., as part of an experiment in long-range communications undertaken for the Air Force.* "Information about the location and distribution of the dipoles will be released as soon as it becomes available, to enable astronomers to participate in the observations," the laboratory said. "The precise location of the orbit must be provided to astronomers because of the great difficulty in locating these dipoles without prior information."

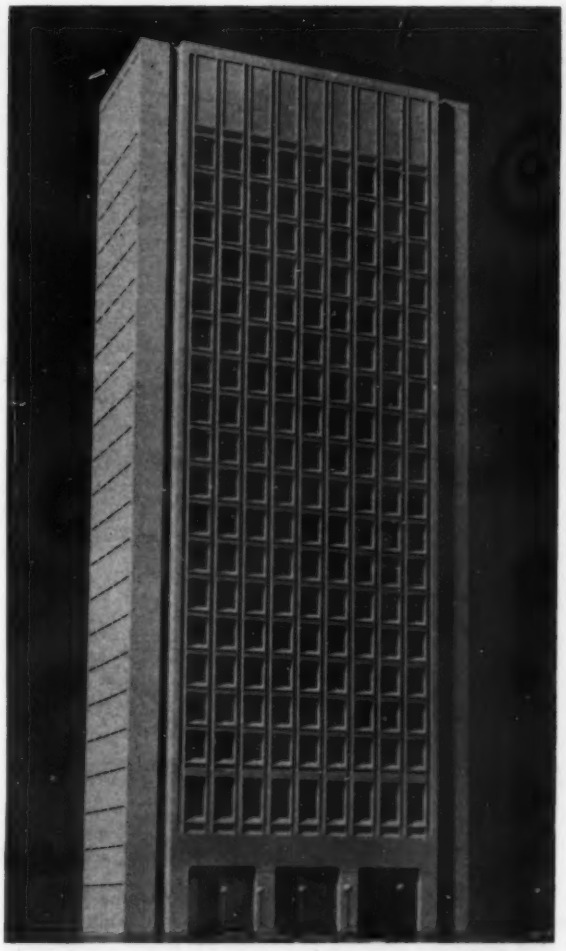
The Omega Meson Is Found

HOW MANY fundamental particles are there? New ones have been found, at a rate of about one a year, for so many years now that it is reasonable to wonder whether those with very short lives should be classified as new elementary particles or excited states of older ones.

The latest to be discovered is the omega meson. It has 1,540 times the mass of an electron but no electric charge, and its mean life is only about 10^{-22} second. An elaborate study of 30,000 bubble-chamber photographs yielded evidence of the presence of about 80 such mesons in 800 reactions involving other mesons.

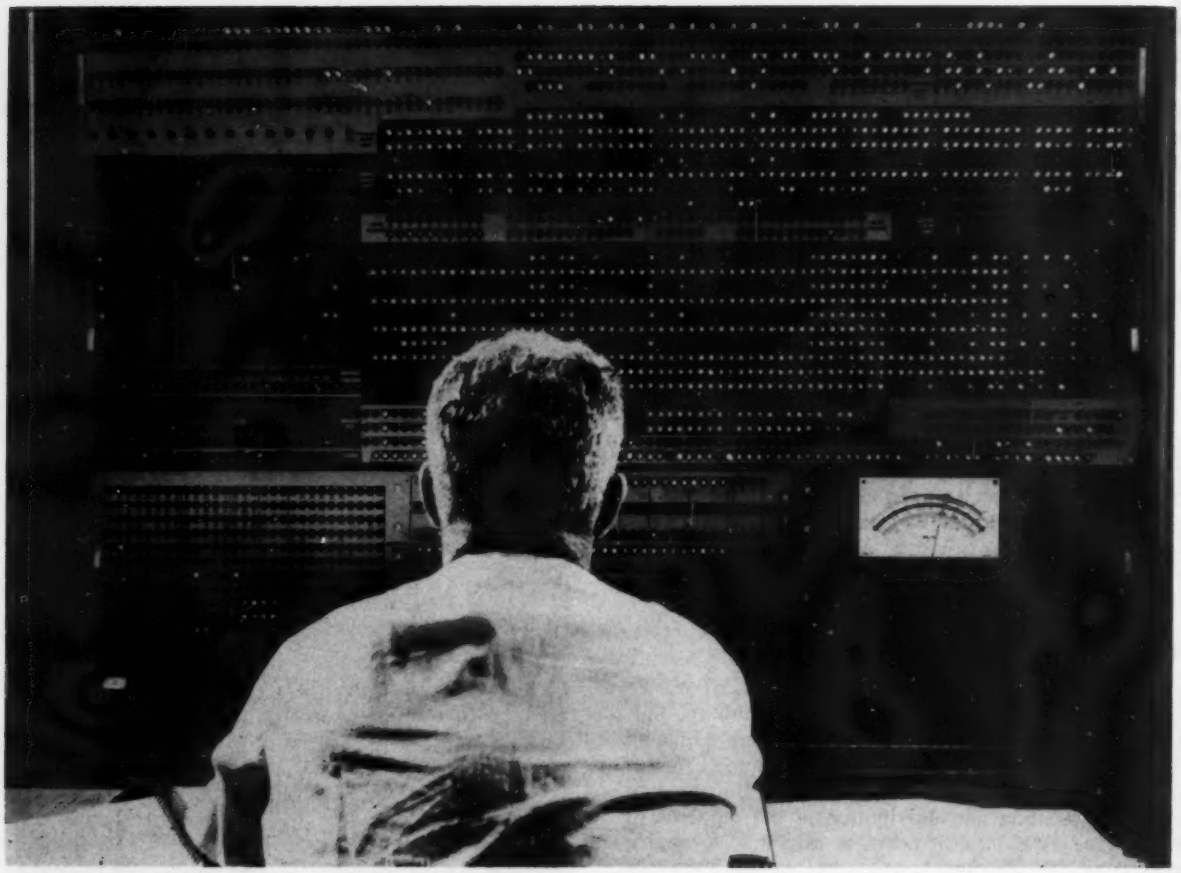
B. C. Maglic, who received his doctorate in physics at M.I.T. in 1959, was a member of the group reporting this work, done at the University of California's Lawrence Radiation Laboratory, in *Physical Review Letters*.

*See "Useful Belts in the Sky," Technology Review, Nov., 1960, p. 23.



PLANS for an Earth Sciences Building at M.I.T. have been revised to keep costs in line. This is the model of the structure that is to be the Institute's first skyscraper.

THREE BASIC MEANS of land-vehicle locomotion—screws, tracks and wheels—are being evaluated as to suitability for the moon's surface in General Motors' Defense Systems Division headed by Harold R. Boyer, '22. The models pictured here have been driven over a variety of soils. Mr. Boyer says workers in GM's Santa Barbara, Calif., laboratories also are engaged in studying problems related to other features of vehicles sent on extraterrestrial missions.



COMPUTING CAPABILITIES next door to the Institute will be impressive when Technology Square, a multimillion dollar industrial research and office center, is completed. Pictured above is the main maintenance console of STRETCH, a giant computer to be operated by C-E-I-R, Inc. Construction of the new home for it began this fall.

Experimenting Freshmen

THIRTY-SEVEN seminars for freshmen were launched at M.I.T. this fall to give freshmen a chance to begin their M.I.T. careers by participating in serious research projects with distinguished members of the Faculty. For both the freshmen and their instructors, these seminars were an educational experiment.

The topics included nuclear chemistry, physics, food supply, oceanography, biochemistry, music, crystal structure, company evolution, and the nervous system. And the work in these and other subjects was planned to take the freshmen into a variety of laboratories, libraries, offices, and industries.

Several of the instructors offering these seminars indicated that their objective would be to give the freshmen a clear conception of research. One proposed to start his group on a project in his laboratory and take them around the Institute to see similar research being done in other laboratories. Another assigned his students to doctoral projects that were already well along and arranged for them to sit in on meetings with graduate students. A third professor said his approach would be quite different: He planned to begin by discussing a few aspects of one of the regular freshman subjects, and strive to show his group how detailed science is and, at the same time, how interrelated its fields are.

Two comments, in particular, reflected concern about the need to make it clear *why* something was being learned.

"I want to demonstrate," said one professor, "that any real engineering problem is tremendously complex. It is not similar to a freshman physics course where only a *principle* is illustrated and elucidated. . . . I hope that when a student gets into an area about which he knows very little, his reaction will be: 'I guess I'd better find out something about this.' "

Said another: "In college courses everything is tidy, and there is a built-in sequence. Hopefully this seminar will have some very untidy problems to work on".

The Kresge Roof Experiment

VISITORS to Kresge Auditorium this winter may notice that two corners of its roof have been re-covered in different ways: Lead plating has been applied to one corner and molded together by heating. Another corner has been re-covered with shingles made of copper and covered by a lead coating.

The whole dome will be attended to later on, because of the weathering of the original roof. But the choice of a new complete covering will not be made until the weather's effects have been observed on the two corners that were repaired differently last summer.

(The Trend of Affairs is continued on page 44)

Learning Corps in Industry

We must take advantage of the homogeneity of skills and knowledge that modern technology has virtually imposed on most production

BY W. O. BAKER

Vice-president—Research, Bell Telephone Laboratories

THOMAS CARLYLE, in *Past and Present,* said: "My brother, the brave man has to give his life away. Give it, I advise thee;—thou dost not expect to *sell* thy life in an adequate manner? What price, for example, would content thee?"

The time has passed when man in our society can be said to have a life in industry. Indeed, considering the mobility of the American population, it would be better to speak, quasi-scientifically, of the half life of man in industry, but even that implies an involvement in the affairs of the worker which has been fading in the last decade. The factories of the industrial revolution, the mill towns of New England, and the industrial centers of the Midwest have certainly marked a period in which laborers, some engineers, and many managers committed much of their lives to—and were contained for much of their lives in—the industry itself. The sleek new electronics plants of Route 128, the Santa Monica strips, and the chemical and petrochemical complexes along the Houston ship canal—even the great Morris Works of a steel company with its Levittown nearby—no longer capture any principal part of the lives of the individuals who work in them.

Symbolically, these plants are strung along great highways so that they are mere stopping points, not quite rest rooms or filling stations, but only shelters along the way, for a society whose inner life finds neither its sole sustenance nor major spiritual satisfactions in the assembly line, the construction gang, or the needle room. Of course the needle room and the construction gang still exist and offer opportunities for individual skills, and even kinesthetic satisfactions, that go with the exercise of such skills. But the direct interest of the worker in his handicraft is lessened and nothing has been developed yet within industry to fill the partial vacuum in his affairs. The intrusion of activities outside of the industry of the working man or the professional man is now so extensive that he no longer has what was char-

The early New England mill towns captured more of the lives of their workers than the sleek new plants along Route 128.

acteristic of advanced civilizations for about two centuries, namely, a life made by industry.*

This theme is possibly shocking at a time when industry has pridefully accumulated an extraordinary range of amenities for its workers. These include good lighting, air conditioning, soft music, free luncheons, on-site athletics, etc. Industry did this under the sincere but outdated belief that people were going to live their lives in it. There is hardly more touching evidence of the anachronistic devotion of our social system to this theme than the law, of at least some states, that workers injured while playing softball or other games on company premises during the day are subject to Workmen's Compensation.

Managers and Union Leaders

In the face of this humanistic trend, I am forced to report I believe that to an increasing degree lives will not be lived in industry, or at least in the industrial circumstances we associate with factories, machinery, distribution systems, and the like. Oddly, there are two residual components of industrial society that seem to be only slowly aware of the detachment of workers' lives from the industries in which they work. These are the managers, particularly the executives, and the union leaders. Both of these large groups recognize too little of the dramatic flux of science and technology through industry. They have been slow to see that work in industry is no longer an activity demanding that lives be lived in its pursuit. Nor have they admitted yet that the specialization of the industrial worker is disappearing.

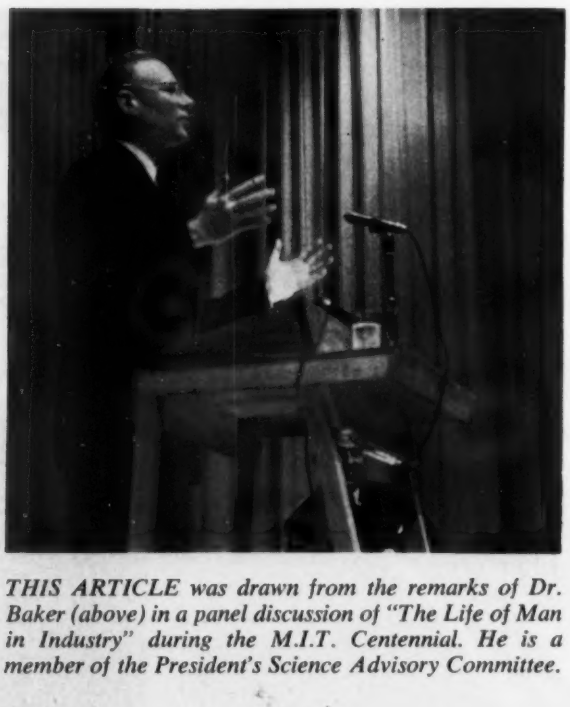
The triumph of using machines and, in these latter years, of the control of machines through servo-feedback electronics, communications, and information theory, has made it possible to design the machine for the product that industry needs to turn out, instead of designing the man for its production. While this transition, astonishingly rapid as it has been, is obvious to engineers and certainly to sociologists throughout the Western world, it has been ignored or missed by many managers and union leaders. The managers, devoted and bound as they are to a particular product, and apparently tied to an annual profit (or, as in defense industries, to a tangible contract result), believe that human skills and energies specifically applicable to their operation must be purchased and developed. The union leaders, on the other hand, have long held the now archaic belief that the nature of the work which people do is the strongest tie to bind them together in their social interests, and thus that the industry of coal mining is quite separate from construction and road building, even though fundamentally the technologies are intimately joined.

Education and particularly its embodiments and its accessories, science and engineering, have played a major part in achieving a state in which man's life is fabulously enriched by results of industry but in which industry progressively requires less and less of his life in it. This is because machines, which started out to be only mechanical levers to extend the muscle and reach of man, are now subject to controls, mostly electrical controls, of such elegance and logic that, in general, man does not find his challenge, or even a measure of his worth, in his direct role in production. He does not have his handiwork in the automobile as the carriage maker did; he does not have his fingertips in the textile as the weaver and the spinner did; he does not have his eye and touch and sense of consistency in the plastic molding or the metal casting as his predecessors did. He does have his part in the control of the machines, but that part is an increasingly technical one, in which the skilled but nonprofessional worker finds his major satisfaction in *learning* and taking *training* for doing rather intricate maintenance and checking jobs.

He need not identify himself with the product much to do this and, accordingly, has no reason to feel that he is using his best talents and fulfilling his ambitions by turning out, specifically, better mouse traps, light bulbs, or rocking chairs. Rather, he may subconsciously think how his training and experience in control and machine operation prepare him for a much broader role. At least, they equip him to perform in almost any kind of industry wherein, with prophetic foresight, engineers long ago selected rather universal types of switches, push buttons, dials, gauges, and recorders. In the mind of the worker a shoe has very little resemblance to a television set (although the two occasionally meet in anger). The machines which make shoes and those which make the components for television receivers do have similar enough linkages with man through their dials, buttons, and switches, however, so that the worker, as he is trained and educated thinks less and less about his life in a particular industry or association with a particular product. He sees more and more how he is a truly interchangeable part, able to perform about as well in one place as another.

How devastating this must be to the product-devoted manager, to the industry-dedicated union leader, and certainly to that vast horde of the new business class—

* Thus, during these centuries, work in industry was an actual saving from want and starvation. For any individual, this is no longer true. Consider, too, the increase in Western man's life expectancy from 40 to 70 years during M.I.T.'s first century.



THIS ARTICLE was drawn from the remarks of Dr. Baker (above) in a panel discussion of "The Life of Man in Industry" during the M.I.T. Centennial. He is a member of the President's Science Advisory Committee.

The man's part in production is becoming more technical.

the service groups. For in sales, distribution, advertising, accounting, etc., one's life may well be in a particular business and be strongly centered in a particular product, but this cannot in our present sense be called a life in industry. So this large cleavage between the lives and loyalties of those who produce and those who sell and distribute—the one becoming more detached from industry and more universal in the application of his skills and ambitions, and the other becoming more and more specialized in being able to sell the advantages of one special kind of dishwasher or cough drop—is a striking result of science and technology.

The Steps Needed Now

If we accept this theme that science and technology are removing the differences between industries, detaching the worker from the product of his work, and imposing some form of the Universal Machine in between those two, then many steps ought to be taken soon to capitalize, in our culture and for our national welfare, on these circumstances. Most of these steps will involve some stage of education, of training, of learning so that, as a man's life grows out of industry, he will feel, nevertheless, that the principles of science and technology that led to the machines and methods of modern production also can lead to enriching his own understanding, even in the most modest form. The principles of levers, of gas laws, of heat transfer, of light generation and focus, and of basic electrical circuits, are surely within the mental grasp of most of mankind. Education has made a great start in relating these to man's life in industrialized technological society. We must now go farther in both education and in industry in teaching every man to feel how versatile his role can be in production.

The nucleus of all this would seem to be that the old notions of science and technology causing increased specialization in the labor forces, or at least preserving the old specialization, must be abandoned. Industry, by vigorous and imaginative teaching and training, must continue the presently improved secondary and college educations of workers so that, from board cutter to Board Chairman, they will be able—and know that they are able—to convert quickly and smoothly from one industry, one production, to another as the demands of the economy and national security require.

While nowadays, both domestically and globally, the gross national product of a nation is regarded as an important index of its strength, everyone realizes that this measure means something only when the goods and services that are produced give adequate answers to the most urgent demands of a particular time. A huge national output of horseshoes means little to our nation now, although it still may be very important to some other economies. The same thing has often been said of tail fins. Planned societies use progress in science and technology to increase the national product in certain, specified ways. We use such advances to meet the demands of a free market, operated by the profit motive, which is well suited to the ways of free men.

Somewhere in between these practices comes a situation resulting from international tensions and competition in which a free society has to be ready to convert its production capacities to provide specific elements of national strength. The significance of the 3 per cent per year increase in our real gross national product since 1929 is blurred by a large but unknown content of growth which may bear little on our race for international peace and leadership. But there is little doubt that no less than 0.8 per cent of this annual growth is due to increased employment. Do we see in that continuing increase in the labor resources of the nation a quality of flexibility, versatility, and modernity which we have all come to demand from new machines and methods in the same period? Have we recognized with proper foresight the depreciation of human resources operating in the rapidly changing technical environment of industry? Have we attempted earnestly to develop, with full appreciation of human qualities, the interchangeable man with anything like the talent we have devoted to the evolution of the interchangeable part?

Some economists would argue that we have done pretty well with this. Professor Robert M. Solow of M.I.T., for instance, reports that "the historical increase in the education of the labor force" is the basis for about 0.7 per cent of the total 3 per cent cited. This can be compared to estimates that 0.5 per cent of all the growth has come from actual advances in technical knowledge and improvements in production practices. Although it seems to me that the sizes of these two factors, which incidentally add up to about 40 per cent of the growth of the last three decades, are hard to identify separately, the combination of the education of the working force and the application of science and technology has clearly been a decisive factor in our growth. But this is not the point being made here: We are emphasizing that the quality of the gross national product in a free society must be made increasingly adjustable to the international demands on our country. This can be done by taking advantage of the homogeneity of skills and knowledge that modern technology has virtually imposed on most of industry.

Teaching machine breaks may some day rival coffee breaks.

This pervasive community of labor and engineering skills may also offer some answer to the call for action so stirringly expressed in Dr. Land's commencement address at M.I.T. in 1960, entitled "On Entering the Majestic Stage of the American Revolution." He contrasted the social differences between the overriding quest for excellence which we now support and the quest for perfection which, he said, "in the domain of the known could involve all of our millions of merely talented people and all of our tens of millions of merely competent people." I believe that the present and oncoming homogeneization of knowledge and skills for the production of goods and services will permit us to afford education and training, from elementary school on through any industry, so that the bulk of our industrial force will be able to gain some measure of the cultural satisfactions that Dr. Land described.

The Excitement to be Caught

This will require, of course, some drastic changes by the two governing elements of an American industry, the union leader and the executive. The union boss of the International Brotherhood of Stemwinders will have to recognize that the training of workers in the elements of physical science, basic mathematics, and machine construction and automatic control, will soon cause them to lose interest in the allegedly unique qualities of the trade of stemwinding. More than that, it will make them lose any valid identification with a special art or craft. Similarly, the executive of production enterprises will have to recognize the astonishing mobility of the labor force which will result from this emphasis on training and education. He will have to stop thinking in terms of a limited specialized labor resource—and I am including foremen, engineers, and many other skilled elements in this. He will have to stop trying to hold his force over the years on the basis of narrow skills or commitments to a particular kind of industry or product.

More importantly, the organizers of both industry and labor will have to arrange for the continuing education of all classes of industrial workers to keep up with what will be a continuing revolution of machines and control techniques. At no stage must it be implied in the factory what is daily implied in the sales department—that a perfection and end of knowledge about the product or process has been achieved. Rather, we must capture the excitement which our population now finds in the novelty of the television drama or even more in the space science and satellite experiment. We must capture that for monthly and yearly, if not daily, progress in the factory.

While the amenities already mentioned of canned music and recreation rooms were apparently designed to take the worker's mind off his work, other techniques of even greater appeal are in prospect which will attract his mind back to the subject, if not necessarily to the task itself. The teaching machine break may some day rival the coffee break. Our preliminary experiments in actual industrial operations with the teaching devices give special meaning to this. Taking off from Professor B. F. Skinner's studies, our investigation of teaching electricity and magnetism to craftsmen show that a wide section of our population is keenly interested in continuing to learn about the fundamentals of the physical world. Indeed, the successor result to that of the Hawthorne experiments, which showed that the workers responded vigorously to the study of their working practices, is the indication that they likewise respond to the study of their work.

So, let our schools and our industries take part in man's whole, bigger life by teaching, even if ever so modestly, through the universal language of science and technology. Why should not the methods shown by the Physical Science Study Committee, and the similar programs in mathematics, biology, and chemistry, be applied? Already, of our 65 million jobholders, only 7 per cent are "laborers." Of industrial classes, craftsmen and foremen are 20.1 per cent and machine operatives 20 per cent, with professional and technical people already nearly 10 per cent.† Already, there are opportunities enough in this population to bring forth able, intelligent, and willing recruits to a study and learning corps.

Let education and industry learn to employ at all levels the workers' minds, in a continuing study based on the simple principles of science and technology. Our faith in the basic aspirations of most men will carry us through a transition period, past the "boondoggle," "wasted-time" stage, into an era of versatility, of real mobility so that the labor force of industry can keep pace with automation and technical growth. A decade before M.I.T. was founded, Cardinal Newman wrote of still other benefits of the course we propose, the humanizing effects: "Hence physical science generally, in all its departments, in bringing before us the exuberant riches and resources, yet the orderly course, of the universe, elevates and excites the student, and at first, I may say, almost takes away his breath, while in time it exercises a tranquilizing influence upon him."

† Managers, sales and service workers, clerical, and farmers make up the remaining 43 per cent—and they are not uninterested in the nature of the physical world.

Rocketeers Win Prize for Safe New Fuel

Two Cambridge students, Franklin J. Kosdon, '63, of M.I.T. and Ronald H. Winston of Harvard, received the American Rocket Society Undergraduate Student Award this fall for their original paper on a new technique for making and casting a solid rocket propellant. The fuel is the first that is safe and can be made easily available for use by amateur rocketeers.

Producing one's own fuels, as amateurs have often done, can be a dangerous and inefficient procedure. The propellant developed by the M.I.T. and Harvard men combines desirable physical properties—high specific impulse, relatively constant pressure, and predictable performance—with characteristics that make it safe and easy for amateurs to use.

The $1,000 American Rocket Society Award, donated by the Chrysler Corporation, was won in 1957 by J. Reece Roth, '59. This year it was presented on Space Education Day during a week-long "Space Flight Report to the Nation" arranged by the society in New York. Senator Jacob Javits of New York, officials of the rocket society, and about 500 students and teachers attended the presentation luncheon.

The winning paper by Kosdon and Winston was entitled "Experimental Development of an Isocyanate Solid Propellant," and gave their evaluation of a propellant mixture with improved casting characteristics. Kosdon is a physics student and Winston is majoring in English but has a good background in chemistry. Together they found an organic chemical that would produce a rubbery solid propellant.

Both young men became seriously interested in rocketry when the Russians launched Sputnik I. "I got angry and very interested," says Winston. Kosdon, the son of a lawyer in Ventura, Calif., won an honorable mention for a Science Fair exhibit of a rocket capable of sending a mouse 42,000 feet into space. Winston, whose father is in the industrial diamond business in New York, helped his father and worked in his home laboratory before coming to Cambridge.

R. Winston (left) and F. Kosdon, '63, testing a fuel.

They met as freshmen and began their collaborative effort to develop their solid propellant fuel a year ago, working nights in the basement laboratory of the M.I.T. Rocket Research Society. Using its static firing facilities, they could measure and record very accurately the chamber pressure and thrust. They carried out an extensive static firing series—137 in all—and had no failures in 40 firings of the final fuel formulation.

They did not decide until mid-June to enter the American Rocket Society competition. The deadline was July 1 and they were 3,000 miles apart, but by sending material back and forth across the continent they produced a 33-page paper that was hailed as "the best paper written by any undergraduate concerning the art of rocketry."

Two sides of the test cell during a static firing by student members of the Rocket Research Society at M.I.T.

Krakatau Revisited

The danger of another eruption like the one in 1883 appears to be remote despite spectacular explosions in the last decade

BY ROBERT W. DECKER, '49
Professor of Geology, Dartmouth College

In new activity in January, 1960, Anak Krakatau sent gas and ash from 1,000 to 3,000 feet into the air repeatedly.

IN THE Straits of Sunda, at 10:00 A.M., on August 27, 1883, after a day of several large preliminary blasts, the volcanic island group of Krakatau unleashed nature's largest well-documented explosion. Fine debris was lifted 50 miles above the islands on the huge expanding gas cloud. The detonation was heard in Australia, more than 2,000 miles away, and the shock wave registered on barographs around the world. Measurable amounts of debris fell over an area of 300,000 square miles, and the dust that was carried high into the atmosphere encircled the equatorial regions of the earth by September 9.

The circuits of dust in the high-speed, high-altitude equatorial easterlies gave meteorologists an early clue to winds that they were unable to measure directly for another 50 years. Arms of the dust spread both north and south, and nearly the entire habitable world witnessed strange and beautiful atmospheric phenomena during the fall and winter of 1883. Perhaps the sunsets were the most beautiful, and Victorian artists and poets recorded them for our imaginations.

Had the fierce ashes of some fiery peak
Been hurled so high they ranged about the globe?
For day by day, thro' many a blood-red eve,
The wrathful sunset glared . . .

TENNYSON

Wrathful indeed had that been radioactive dust!

Krakatau was fortunately a group of uninhabited islands, but the great explosion was not without catastrophe. Large tsunamis or tidal waves, related to the apparent collapse of the volcano into the void evacuated by the great eruptions, circled outward from the islands and reached the shallow shores of the Straits of Sunda from one-half to one hour after the explosion. Depending on the shape of the shore line, these great waves built up to heights of over 100 feet, swept inland as far as 15 miles over the flat coastal plains, and killed 36,000 residents of Java and Sumatra in a matter of minutes.

The missing part of Krakatau was five miles long and two to three miles wide. Where a peak once stood 1,500 feet above the sea, there is now a hole in the sea floor more than 800 feet deep! It has often been said that Krakatau "blew its top." But the 18 cubic kilometers of erupted material was largely pumice, a frothy natural glass so full of gas bubble holes that it floats on water. It choked the Straits of Sunda like a great ice pack for weeks after the eruption. The missing island was built of more dense lava of different composition. Both the new rock material and the great tsunamis are best explained by a collapse of the volcano into an underlying evacuated chamber which once held the molten, gas-charged rock. Similar great circular depressions are found in other volcanic regions and many of these *calderas* are thought to be of collapse origin. Crater Lake, Oregon, is one of the most beautiful and well-known examples.

☆ ☆ ☆

Quiet returned to Krakatau as it had for 200 years before the 1883 disaster, but in 1927 a new series of eruptions began from the submerged rim of the 1883 caldera. By 1930 the new volcano reached the surface

The new volcano is a mile wide, 500 feet high. Rakata Island, in background, is remnant of the eruption and collapse in 1883.

of the sea and a new island, Anak Krakatau (child of Krakatau), was born. This new volcanic cone is built entirely of solid ejecta. Instead of molten lava spewing forth from the crater, molten rock solidifies below the surface and is blown out by gas pressure. This type of volcano grows like a giant anthill. The loose, porous material is easily eroded by sea waves and currents in an island setting, and Anak Krakatau has wavered between growth and destruction through alternations of eruption and erosion. The latest periods of important activity were in 1953 and 1960.

The 1960 activity was sufficiently strong to refresh memories of the 1883 disaster, and the Indonesian government sponsored an expedition to the islands to gather new scientific data and to ascertain, perhaps, the danger of any future caldera collapse. In the 1883 disaster and in the geologic remains of a similar prehistoric collapse at Krakatau, there is a definite sequence of compositional change in the erupted rocks, beginning with lack of silica in the early eruption and growth stages and ending with excess silica in the pumice eruptions of the caldera collapse. The present eruption products of Anak Krakatau are still basalts which lack free silica. So, on this criteria, there seems little danger of a new catastrophe in the near or foreseeable future. Although spectacular at close range, the recent eruptions of Anak Krakatau are relatively harmless.

Explosions of steam occurred 30 seconds to 10 minutes during two days that the writer was on the island. These would form mushroom clouds turbulently rising from 1,000 to 3,000 feet above the crater and heavily laden with volcanic ash and cinders. During the larger explosions, showers of hot, solidified lava blocks, up to several feet in diameter, landed nearly 2,000 feet from the vent. A new map revealed that Anak Krakatau has grown to one mile in diameter and a height of 500 feet. The high point is on the rim of an outer crater nearly 2,000 feet in diameter, and the recent explosive eruptions have produced a new cinder cone inside the older crater. The volume of the island is 0.3 cubic kilometers and continued growth similar to that in the last 30 years will rebuild it to its 1883 volume in about 600 years.

With the aid of a seismograph the depth of the 1960 explosions was found to be roughly from 600 to 700 feet below sea level. From this starting point the exploding gases, largely steam, would take 15 to 25 seconds to churn their way upward through the loose material choking the vent before breaking out at the surface and forming the turbulent explosion clouds. The black, ash-laden clouds would rise rapidly, often laced with lightning bolts generated by the static electricity of the moving particles, until the expanding gases reached temperature and pressure equilibrium with the atmosphere.

(Concluded on page 50)

Talk of Our Times

What Mineral Engineering Needs

At a meeting of the Natural Resources Committee of the National Academy of Sciences last fall, PROFESSOR A. M. GAUDIN *of M.I.T. called attention to problems in mineral engineering that require study, and asked: Who will do it? Professor Gaudin said in part:*

RESEARCH in mineral *engineering* must go all the way to practical utilization of the idea. The day-to-day grind is often monotonous, and does not stand up well in young men's minds with the thrill of first trapping a strange particle or setting up some new mathematical observation that, the student is told, will revolutionize men's ways. This is the philosophical handicap that the mineral engineer meets when he tries to gain young recruits.

The competition for young people is made more severe by the practical test of the ads in the newspapers which play up, unwittingly no doubt, the advantages that will accrue to one who follows exotic material in the realm of outer space.

No one in his right mind will dispute the importance of these new areas of activity, and I do not propose to do so. It will suffice for me to bring to your attention that this year out of some 60 students admitted to the Graduate School in the Department of Metallurgy at M.I.T. there was not a single American seeking to perfect himself in mineral engineering, and there were only three or four in extractive metallurgy.

Part of the responsibility for this lies in the companies that excel in mineral processing and the extraction of metals. They have awakened only recently to the need for research personnel in their field. Fifty years of deliberate ignorance take more than a few years to correct. And yet correct it we must, as I became convinced after a trip to the U.S.S.R.

I visited eight institutes there dealing with metallurgy, coal beneficiation, geochemistry, mineral engineering and mining. Each was many times larger than its U.S. counterpart. At the Moscow Institute for Rare Metals and Gold, some 500 metallurgists, specialists in the narrow range of rare metals and gold, are graduated yearly. Quarters are not too good, but the spirit is there, and the curriculum—five years—equals that for the master's degree at the best U.S. schools. In Leningrad, at the Institute Makhanobr, dealing exclusively with ore-treatment problems of ferrous metals, there were some 1,600 employees. Their numbers were increasing, new quarters were being built, and new institutions in western Asia and the Ukraine spun off.

We have a big personnel problem building up in this country, and the situation will become worse before it becomes better. Despite the lack of good American students in mineral engineering, I find the business administration field well staffed with would-be Presidents and Chairmen of the Board, who have Boston, New York or San Francisco as preferred locations, and who are willing to have a very brief brush with mineral problems—so, no doubt, as to be able to boss around the clods who stay in the mineral field. And I find plenty of foreigners wishing to become proficient in mineral engineering: Germans, Austrians, Frenchmen, Hindus, Chinese, Japanese. And also, thank goodness, some Canadians.

This situation could be corrected, not overnight, but in five to 10 years, by taking a leaf from the Russian book. They have placed the incentive of a better future before the younger generation. Each man on reaching college age is automatically employed, and paid. He goes to work in a factory *unless* he has been admitted to college. If he has been admitted, he is paid, at about the same rate as an apprentice in, say, a machine shop. Each year brings him a raise in pay until his graduation, when the first big step forward occurs. If a student fails, he goes back to laboring for a year or more. With such a system there is no dearth of applicants for "positions" as students in a college.

What I propose is the creation of research fellowships for men who have already earned their doctorates, at competitive rates of pay, and for sufficient time, say four years, for each fellow to do something worthwhile. Even if we were to allow $25,000 per man per year, as an all-inclusive cost figure, this, on the basis of a thousand men per year would only cost $25 million, or less than a submarine. On the basis of 400 men per year the cost would remain in the range of $10 million, a paltry sum, indeed, when the stakes are duly examined. And the stakes include pre-eminence of the United States in the mineral field. . . .

Mineral engineering research problems abound. We need, however, a general national awakening to the reality of those problems.

Science Vs. Magic

Administrators who are not technically trained still often confuse science with magic, GEORGE E. VALLEY, JR., '35, *Professor of Physics at M.I.T., told the Air Force Association at its convention this year in Philadelphia. Professor Valley called attention to seven characteristics of science and technology that differ from those of magic:*

1) NO FACT of science or product of technology, however it may be classified, can be known to but a single man.

2) The benefits of science and technology can accrue to any one of us only through the co-operation of many people.

3) The benefits of technology can accrue to a particular person not simply because he is that person but because he is enabled to place himself physically in position to receive those benefits.

4) The devices of technology are fallible, sometimes they need repair.

5) The knowledge and the predictions of science are never perfect, perfection being regarded as an approachable but unattainable limit.

6) Technological devices unlike magical ones neither protect their users from harm nor do they necessarily cause harm to people.

7) From science and technology you do not always get what you want; all you can have is what men know how to make possible from their always imperfect understanding of nature.

Instrumentation Developments and the Potential of Nations

Integration of the wealth of material available about methods, to make it manageable, is the objective of work now under way

BY KURT S. LION

THE NATIONAL POTENTIAL of a country includes more than its ability to produce raw materials and consumer goods, to provide and maintain public safety, and to protect its population from internal and external enemies. A nation also has a cultural potential when promotion of the sciences and the arts is a part of the national mission.

Nations differ considerably in the pattern of topics that form a national mission. Sometimes lately, the potential of a nation has been equated with the ability to put a man on the moon. Such a feat, however, represents but a small part of the potential of a nation, a part with a significance that must be judged on the basis of its priority, its economic sanity, and its publicity value.

For many countries the scientific potential is an important part of the national mission. In the Western nations the discovery of a new subatomic particle, or the invention of a bubble chamber for studying nuclear fragments, is considered a national accomplishment. Science has laid the groundwork for the economic development of these countries and has increased their production potential and their potential ability to safeguard their people.

The discovery of polio vaccine has been celebrated as a national accomplishment even more than any discovery in physics or chemistry. When an anthropologist, in the years to come, studies "the American way of life," he will probably find that the social prestige of the medical research worker exceeds that of any other research worker, entertainer, or sports hero.

The influence of the scientific potential of a nation is probably greatest, nevertheless, in its military applications, and many countries feel forced to spend considerable sums to increase their scientific potential because of their need for defense. Sovereigns and commanders of military forces, at all times, have employed technical experts, and technical experts have frequently earned their living by working on military projects. Well known, for instance, is an "unsolicited proposal" that Leonardo da Vinci submitted in 1482 to the Duke Ludovico Sforza in which he proposed to develop portable bridges, ballistic machines, and other military equipment. Only at the end of his proposal did he mention that he would like to build a beautiful bronze horse.

DR. LION, who is shown at the right working in the basement shop he has in his home in Belmont, is associate professor of applied biophysics at M.I.T. This article is a condensation of a lecture he prepared for an Instrument-Automation Conference in Los Angeles last fall, and is published with the permission of Herbert S. Kindler, '48, Director of Technical and Educational Services of the Instrument Society of America. Professor Lion will help give a short course in Measurement Engineering at Arizona State University next January 29 to February 2 and also is scheduled to teach instrumentation in Mexico City next spring.

Instrumentation's Role

Research in the natural sciences depends critically upon instruments and methods. When a new idea is conceived, it is tested by experimental means; a method is worked out, and the necessary instrumentation is procured or, in many instances, newly developed.

Many scientific investigations which at the time of their publication were considered pure science later have become the basis for instrumentation topics. The classical investigations by Langmuir, Schottky, and others on the emission of electrons from metals, for example, was the basis for the development of that very important contribution to instrumentation, the electronic amplifier.

The scientific world has long acknowledged the equality of instrumentation and pure science. Of all Nobel prizes awarded to physicists and chemists, more than 50 per cent have been awarded for accomplishments in instrumentation. In 1960, the Nobel prize in chemistry was won by Libby for the development of a method for determining the age of organic materials by measuring the radioactivity of the carbon isotope C^{14}, and the Nobel prize in physics went to Glaser for the invention of the bubble chamber. Similarly, the 1959 Nobel prize in chemistry went to Jaroslaw Hey-

Such items as coffee still manage to evade thorough evaluation by instruments . . .

rovsky for his invention of an electric instrument for quantitative and qualitative chemical analysis, the polarograph.

Some industries are now highly developed as far as the application of instrumental methods are concerned; these include the electronics, petroleum, electrical power, and business-machine industries. But there are others that still rely relatively little on instruments and instrumental methods; these include the food, the leather, and, to some extent, the textile industries.

This may be understandable, not only on an historical basis, but more so because primary transducers for many aspects of these industries do not exist. Taste and smell, for instance, have always been physically evasive qualities, and the quality of such items as beer, soluble coffee, butter, perfume, etc., still is evaluated by human testers. There are efforts that may lead to transducer developments in taste and smell measurements—such as gas chromatography and ionization chamber gas detectors, systems that are capable of detecting a concentration of certain gases by only one part in 10^{14}—but the technical difficulties are considerable and the applications are, as yet, uncertain.

Automation now is one of the most challenging fields in instrumentation, and it frequently requires the development of new transducer systems. The control of the dynamic behavior of automation systems often requires great mathematical and experimental skill and not infrequently the use of computers and analog models. But the rewards can be high; increased production potential and less costly consumer goods can be expected, along with a shifting of labor from monotonous low-grade work to intellectually higher, and probably better paid, activity.

The influence of instrumentation in biology and medicine is growing, too, at an accelerated rate. The greatest need for instrumentation is found, of course, in medical *research,* but potential applications of instrumentation may exist also in connection with the diagnosis and the treatment of diseases. An inspection of the program of the last international conference on medical electronics shows a wide variety of topics in the borderline field of instrumentation and biology.

Special techniques, in particular instrumental systems that give information about chemical and biochemical processes in living matter, may be of particular importance in future biological research; these include potentiometric, polarographic and conductimetric systems, systems of chromatography and gas chromatography, and such detecting systems as the ionization chamber, the thermal conductivity chamber, and similar transducers. Spectrophotometry, particularly in the infrared region, has contributed considerably to the biological research potential, and the influence of the mass spectrograph and of the magnetic resonance spectrograph is still rising.

Now, too, a different type of instrumentation, the methods developed in the fields of communication and computer technology, is gaining ground in biological and medical research. Small signals of biological significance in the presence of high-level noise pose problems which instrumentation can solve. But the difficulties are considerable and instrumentation systems of high complexity may be needed to compete with humans.

An example of this type of problem is the measurement of the heartbeat of the human fetus in the presence of the heartbeat of the mother and other noise sources. The skilled human observer can easily separate the desired signal from the noise level that exceeds the signal by orders of magnitude. To do this, he correlates the meager information he obtains from his stethoscope with the expected signal or signals that he has stored in his brain. A substantial, complex instrumentation development will be required to compete successfully with this subjective method.

Endoradiosondes, that is, miniaturized telemetering systems that are borne without discomfort or disturbance by the experimental animal or human being, have furnished information of great value and are likely to be more important in the future. The field of bionics, which is primarily concerned with the creation of instrumental systems that closely resemble biological systems, also has reported some remarkable successes and more can be expected.

Integration and Education

The greatest field for the application of instrumentation today, however, is still that of military technology. One can be familiar with only a small sector of this work. It may be regrettable that the enormous amount of ingenuity displayed in the field of military instrumentation is presently available for purposes of defense only, but there is justifiable hope that this ingenuity will serve other purposes as well.

(Concluded on page 52)

An Electrical Search May Aid Archaeologists

Exploration of the Paris of the ancient world will be continued

The marble "soul portrait" at right was found in the debris over the main avenue of Sardis by the Harvard-Cornell expedition last summer.

THE CAPITAL of the Lydian empire in the time of Croesus, and the Paris of the ancient world for many years, was Sardis in western Turkey. For four summers, Harvard and Cornell archaeologists have been working there.

Radioactive dating, electron microbeam probing, and other new techniques can be employed to determine the age and composition of their discoveries. But archaeologists still are frequently uncertain where to dig, and this year David Greenewalt, '60, of M.I.T. joined the explorers of Sardis to see whether a geophysical technique could be employed to reduce the danger of digging in the wrong places. He will return to Turkey next summer to continue the investigation.

The archaeologists are especially interested now in some large burial mounds about five miles north of Sardis. Grave robbers have opened a few stonework tunnels leading from the edges of these mounds to small burial chambers. If more such tunnels can be found, the excavators can proceed more surely.

Geophysicists developed a resistivity test about 40 years ago which sometimes is helpful in locating large deposits of ore. Electrodes are placed in the ground, small currents sent through them, and the voltages read. A change in the resistance between a pair of electrodes may indicate the presence of a deposit of metallic ore.

This technique also may help locate buried structures. If the ground, or fill, in a given area is reasonably uniform, a buried stone building or wall may change resistance to an electric current. By taking enough readings, a pattern may emerge to guide excavators.

University of Pennsylvania searchers used this method in Mexico in 1960. It also has been employed in Italy. When conditions were favorable, it has been possible to trace underground walls this way, but not all of the experiments have been successful.

The technique is most helpful where there is homogeneous fill and where there are high contrasts in resistivity between the object being sought and the surrounding material. Archaeologists are intrigued by the technique in many areas because the equipment can be carried in a suitcase, and the tests can be made quickly and inexpensively. Professor George M. A. Hanfmann of Harvard, one of the leaders of the Harvard-Cornell expeditions, hopes it can be helpful in Turkey.

Last summer the expedition uncovered the grand shopping street of Sardis and found colorful mosaic flooring laid by the Romans in the Fourth Century A.D. Many unusual works of art were found, too. These included a delicately adorned gold bead in the tomb of a lady who lived in 600 B.C., the century of the father of Croesus; and a "soul portrait" of an unknown saint or sage which Professor Hanfmann says "well expresses the spirit of transition from the Roman to the Christian world."

This Late Roman (Fourth Century A.D.) mosaic floor in a villa in Sardis was uncovered last summer. The excavators will resume work in the area next year.

Institute Yesteryears

25 Years Ago . . .

IN DECEMBER, 1936, Karl T. Compton, President of the Institute, delivered his valedictory as President of the American Association for the Advancement of Science. His subject was "The Electron," and he said in part:

"The history of science abounds with instances when a new concept or discovery has led to tremendous advances into vast new fields of knowledge and art whose very existence had hitherto been unsuspected. The discoveries of Galileo, Faraday, and Pasteur are such instances. But, to my notion, no such instance has been so dramatic as the discovery of the electron, the tiniest thing in the universe, which within our generation has transformed a stagnant science of physics, a descriptive science of chemistry, and a sterile science of astronomy into dynamically developing sciences fraught with intellectual adventure, interrelating interpretations, and practical values.

"I take particular pleasure in mentioning these practical values, for even the most unimaginative and short-sighted, hard-headed, 'practical' businessman is forced to admit the justification for the pure research—of no preconceived practical use whatsoever in the minds of those who led in its prosecution and of all degrees of success and significance—which has been directed at the electron.

"For out of this research have come the following things which all can understand and appreciate: a growing business in manufacture of electronic devices which now amounts to 50 million dollars a year in America alone; a total business of some hundreds of million dollars a year which is made possible by those electronic devices; innumerable aids to health, safety, and convenience; and an immense advance in our knowledge of the universe in which we live."

¶ Congratulations were being extended to Charles Camsell, '09, on his appointment as Canada's Deputy Minister of Mines and Natural Resources; to Oscar C. Merrill, '05, elected Vice-president of the World Power Conference; and to Charles Edison, '13, upon becoming Assistant Secretary of the Navy.

50 Years Ago . . .

THE REVIEW reported that, "on Tuesday evening, December 26, [1911], the Cambridge Common Council removed the last serious obstacle that stood in the way of the Institute locating in that city on the contemplated Esplanade site . . . by accepting the report of the Committee on Highways which recommended the closing of Amherst Street . . .

"Although it was generally expected that this would be the final outcome of the matter, nevertheless, from rumors that have been afloat, it seemed not at all unlikely that it might be delayed for a considerable period, and the final action of the Council was . . . heartily approved by the citizens of Greater Boston."

¶ "Although the sophomores as a body ceased paying unappreciated attentions to the freshmen on the night of the freshman dinner, several years ago," the editor of The Review observed that "there has been an annual skirmish of yearly diminishing importance which has generally resulted in the ducking of two or three sophomores in the Frog Pond on the Common. This fall, the sophomores of the Class of 1914 decided to put an absolute stop to this child's play and the freshmen were unmolested at their dinner."

The decision prompted favorable comment in the press and certain magazines such as the *Journal of Education,* which reacted as follows: "The attitude . . . is one that is worthy of commendation as a step on the part of a college where 'efficiency' is the watchword against the silly and useless combats between the entering class and those already in the college. For a number of years the student body, which here more than in any other institution takes the initiative in matters of change or reform, has been struck by the folly of the older custom, and, one after another, objectionable practices have been dropped from the list.

"Formerly the night following 'Freshman Dinner' saw a free fight, long continued on the grounds about the athletic field in Brookline, which was among the most sanguinary of any of these college class clashes which popularly attach the adjective 'bloody' to the day of their customary occurrence. . . ."

75 Years Ago . . .

PRESIDENT FRANCIS AMASA WALKER, in his Annual Report dated December 8, 1886, wrote: "More and more painfully, from year to year, we feel the need of large permanent endowments, to increase the present usefulness, and to secure the future, of the Institute. No school in the land is undertaking to do a work so large as ours, without twice, thrice, or four times our invested means. . . .

"I am speaking in no spirit of complaint or censure. . . . Nor is it a subject altogether of regret, that in the past we have been somewhat pinched for means. The early growth of the Institute may not inconceivably have been sounder and firmer, because slow and painful. But I think no one can know much of this school without having a strong conviction that the full time has now come, when it requires for its greatest usefulness, for the maintenance of its high character among the scientific institutions of the world, and for its security against disaster and business depression, large, very large, additions to its permanent investments."

¶ *Technique 1888,* the second number of that annual volume, "appeared on the morning of the 23rd, and within 15 minutes the first lot of 360 were sold out," according to *The Tech,* which declared itself "as a whole . . . very much pleased with the work, and [considered] it a credit alike to its editors, the Class of '88, and the whole Institute."

¶ The twelfth Annual Meeting and Dinner of the Alumni Association was held at Young's Hotel on Tuesday, December 28, 1886, about 40 members being present. The report of the Secretary and Treasurer was read, showing a balance on hand of $54.06. The Alumni Fund amounted to $1,174.75.

The Soon to Be Completed Electron Accelerator

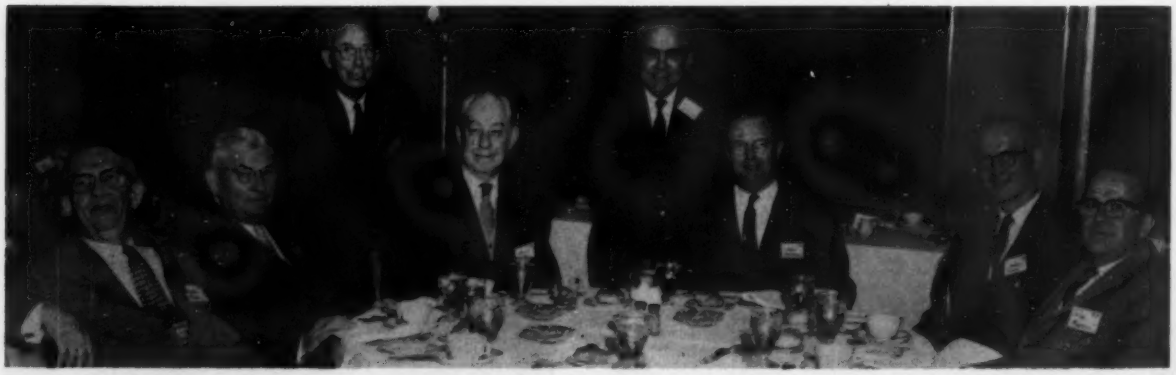
THE M.I.T.-Harvard six-billion-electron-volt accelerator will put electrons to new uses when it goes into operation shortly. *(See President Compton's remarks 25 years ago on the preceding page.)* This view is from Andover Hall of the Divinity School. The big ring of magnets and other key parts of the device are underground.

Radial tunnels carry magnet power conductors, signal and control cables, and the feeder for the r.f. system.

Prof. M. Stanley Livingston and William Holland (right) facing an r.f. cavity. The wave guide is above the magnet.

In New York

More than 400 turned out for National Alumni Night. At the head table directly behind the lectern is A. E. Perlman, '23; and at his left, C. G. Dandrow, '22.



In Detroit

Left to right: C. L. Tuller, '12, F. H. Davis, '04, T. K. Hine, '16, P. C. Baker, '16, J. E. Longyear, '26, J. M. Campbell, '25, H. H. Kehrl, '60, D. B. Martin, '25.

Los Angeles

Nearly 200 attended the Los Angeles meeting. Standing in rear is Ray Stringfield, '15; seated at his left is Second Century Fund Chairman John J. Wilson, '29.

Technology's Voices Cross the Continent

The Institute's Alumni hear a message from the Second Century Fund's leader bounced off the moon—and a few words from DAVO

THOUSANDS of Alumni, meeting in 46 cities on National Alumni Night, October 19, heard "The Voices of Technology" telephoned from Cambridge. Philip H. Peters, '37, introduced them, and the first speaker was Mrs. Karl T. Compton acknowledging "our incalculable debt to all those minds throughout the ages who have extended knowledge or have deepened our understanding of ageless values." President John F. Kennedy and Prime Ministers Winston Churchill and Harold Macmillan were then heard speaking at Institute gatherings, and their voices were followed by those of many of the best-known members of the Institute's Faculty and staff.

Speaking from New York, Chairman James R. Killian, Jr., '26, of the Corporation, reported that $44,000,000 of the $66,000,000 being sought for the Institute's Second Century Fund had been pledged. M.I.T., he emphasized, is an institution observed and copied the world around, which can serve as a great lever to aid in meeting our national goals. "We must permit no obsolescence, no lack of energy, or no financial limitations to prevent us from maintaining and enhancing our leadership," he declared.

Speaking from Boston, President Julius A. Stratton, '23, summed up the Institute's immediate hopes and needs in these words:

"First, to enrich the opportunities for education and to develop quality at every level and in every area . . . Second, to press forward in critical new fields through research and to relate research to teaching. . . . Third, to add to the total educational experience of the student on this campus, and so to contribute to the development of character, judgment, and perspective of each as an individual."

These, he added, "are large and ambitious goals," toward which the Institute is moving "with a conviction of their urgent importance."

From the Pacific Coast, the voice of John J. Wilson, '29, general chairman of the Second Century Fund, was beamed at the moon and reflected back to Massachusetts to be sent throughout the continent. "The sum of the generosity of each one of us in both time and money," he observed, "must be sufficient to prove overwhelmingly that our Alumni will do more than their share in making it possible for this great institution to meet her growing responsibilities to our country and, indeed, to the rest of the world."

Earlier in the program, the Alumni heard Vannevar Bush, '16, reading an excerpt from his famous essay, *The Builders**; Professor Samuel C. Prescott, '94, recalling his days as a freshman 71 years ago; Professor Jerome C. Hunsaker, '12, reminiscing about the beginning of education in aeronautical engineering; Professor Warren K. Lewis, '05, exclaiming in his habitual way, "Now listen!"; Professor Erwin H. Schell, '12, noting that many men from Technology have risen to high places "sometimes unexpectedly"; and Professor Norbert Wiener declaring his work could not have been done "if it had not been for the splendid atmosphere of friendship, of freedom, of ability to work, of appreciation" which he had found at the Institute.

The Deans of five of the Institute's schools were heard, too.

Gordon S. Brown, '31, of the

* Technology Review, February, 1955, p. 178; January, 1945, p. 162.

Professor Hunsaker, '12

Professor Prescott, '94

Professor Schell, '12

School of Engineering, said: "Our dominant goal is to educate young engineers who, as professional men, will work on the truly important areas of their profession, who will be guided by the economic, political, and social consequences of their actions, and who, during their careers will bring forth desired new technologies, the very nature of which are essentially unknown during the period of their formal education."

George R. Harrison, of the School of Science, said: "The solution to the problem of increasing our effectiveness in the School of Science at M.I.T. involves not only physical improvements, such as more ample and modern laboratories and equipment, but, in addition, the development of the ability to teach larger numbers of students and to teach them thoroughly. We must develop appropriate teaching aids and we must discover ways to keep up with the advance of science itself."

John E. Burchard, '23, of the School of Humanities and Social Science, said: "Our program of undergraduate liberal education here at M.I.T. accepts the fact that you cannot make specialists into men of wide vision by exhortation."

Pietro Belluschi, of the School of Architecture and Planning, said: "Architecture and city planning . . . are ultimately concerned with a single objective, creating a more civilized physical environment. The need and the opportunity are now greater than ever before."

Howard W. Johnson, of the School of Industrial Management, said: "We are in the heart of a great technical university, and since business and industry are so intertwined with problems of advanced technology, this gives us special advantage."

There were other memorable voices on the program, too, including those of the late President Karl Taylor Compton and of Alfred P. Sloan, Jr., '95.

"Certainly, we the Alumni would be derelict in our duty to the Institute and to our society, to say nothing of ignoring our opportunity," said Mr. Sloan, "if we failed to appreciate our outstanding leadership and the competence of that leadership, and to rally our loyalty, our confidence, and our maximum effort to the support of Dr. Killian, Dr. Stratton, and their able group of scientists and educators."

Dudley Clapp, '10, was heard again speaking at the 50th commencement luncheon after the graduation of his class:

Now your president has asked me to give you advice:
Half a century's worth in a neat little slice
Though I fear we old fogies don't cut any ice,
Our fond reminiscences bore so.
Just allow me to warn you—your studies aren't through
What you've learned is not all and won't always be true.
Keep alert and receptive to new points of view,
For life is like Tech only more so.

There was a new voice, too, that of DAVO, a machine which simulates the sound of the human voice and is called a Dynamic Analog of the Vocal Tract. It muttered: "Tech is hell." And there was also some eavesdropping on a student and a professor.

"There's the attitude here," said the student, "that, well, we're not going to spoon-feed your education, you're going to have to go out and get it yourself."

"When you teach," Professor Hans Mueller was heard telling the freshmen this fall, "you always introduce certain things, *not* because you expect necessarily that the student will understand it. He is not prepared to understand it. Why? Because we have to say it the first time, we have to say it again a second time, the following term; or the third term, or perhaps the—four or five times more! So we better bring it in the first time already in his freshman year."

The M.I.T. Glee Club provided musical interludes, and Chairman Peters remarked at the telephoned program's conclusion:

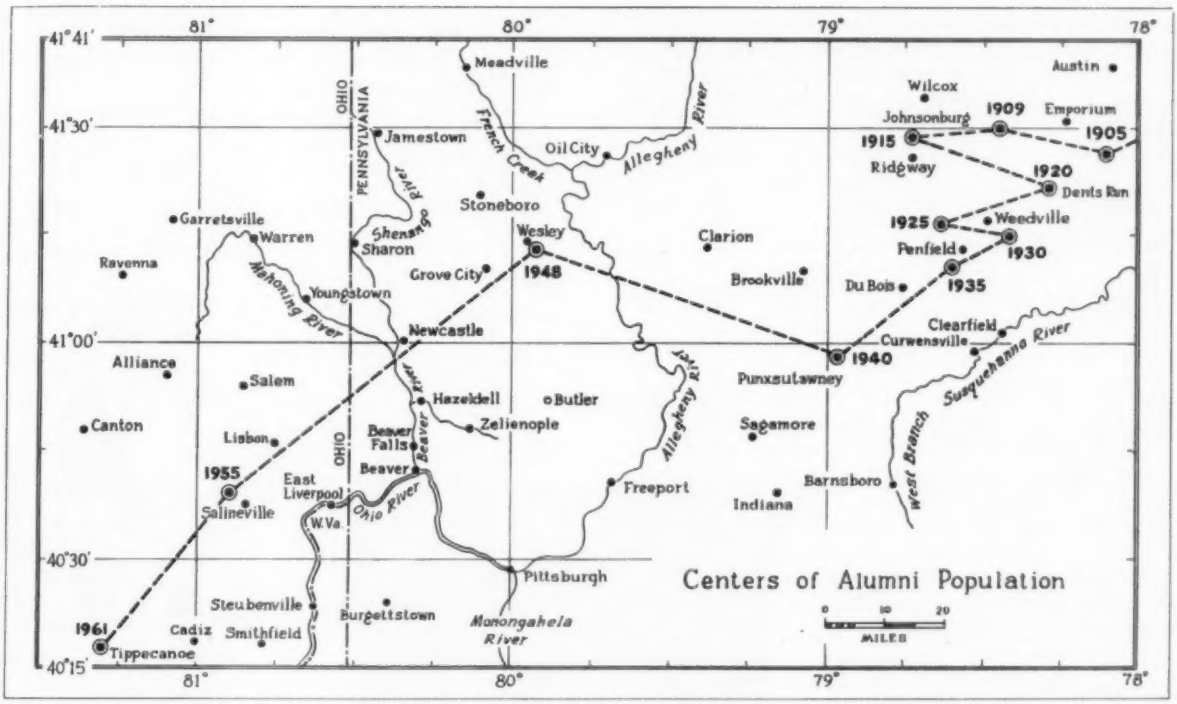
"I speak as national Chairman of the Area Organization of the Second Century Fund in saying that we Alumni have it within our power to be members of this great company of builders (to which Dr. Bush had referred). What we have already done to help M.I.T. has encouraged foundations, corporations, and non-Alumni to give generously. What we do from here on will be watched all over the country and can, *as we do well,* be multiplied many times. We have it within our power to demonstrate to the nation that we can underwrite a great resource, which M.I.T. surely is, a great resource for free men everywhere, and for the achievement of their goals—material, cultural, and spiritual."

Chairman Arnold, '27, presiding at the meeting of Boston Alumni in Walker.

Westward Ho, and Farther South

Where M.I.T.'s Alumni are now in this country and abroad . . . and the companies they serve

BY H. E. LOBDELL, '17



COMPUTATION of the theoretical population center of the 45,754 Alumni listed as resident in the United States by the 1961 CENTENNIAL ALUMNI REGISTER confirms the continuing trend of the center's movement southward since 1948 and westward since 1940—as shown by the map.

The 1961 center, which is 24.2 miles south and 95.9 miles west of the 1940 center, is a point about 1½ miles west of Tippecanoe in Harrison County, Ohio—at latitude 40° 16′ N and 81° 19′ W.

During the 21-year span, 1940-1961, the *average yearly movement* of the M.I.T. center, which was 2.3 miles south and 5.9 miles west, exceeded the corresponding average yearly movement of the population center for the entire country during the 20-year span, 1940-1960, which, as reported by the Federal Census, was 1.2 miles south and 4.8 miles west.[1]

Alumni distribution shifts during 1940-1961 are illustrated in the tabulations at the right, the first of which shows data by regional areas indicating that the North Atlantic region now accounts for nearly 9 per cent *less* of the total Alumni in the United States than in 1940, whereas the Western region now accounts for 5.4 per cent *more* than in 1940.

	1961	*1940*
U.S. Total	*45,754—100%*	*27,108—100%*
North Atlantic	26,994— 59.0%	18,365— 67.7%
North Central	5,972— 13.0	3,338— 12.3
Western	5,893— 12.9	2,028— 7.5
South Atlantic	4,934— 10.8	2,356— 8.7
South Central	1,961— 4.3	1,021— 3.8

Similar comparative data by the leading states show that Massachusetts and New York now account, respectively, for nearly 7 per cent and 3 per cent *less* of the U.S. Alumni than in 1940, whereas California now accounts for over 4 per cent more than in 1940.

	1961	*1940*
Massachusetts	11,614— 25.4%	8,712— 32.1%
New York	6,749— 14.8	4,746— 17.5
California	4,014— 8.8	1,241— 4.6
New Jersey	2,541— 5.6	1,288— 4.7
Pennsylvania	2,450— 5.4	1,384— 5.1
Connecticut	2,004— 4.4	1,001— 3.7
Ohio	1,641— 3.6	974— 3.6
Illinois	1,361— 3.0	915— 3.4
Michigan	1,162— 2.5	428— 1.6
Dist. of Columbia	1,151— 2.5	809— 3.0
Texas	983— 2.1	418— 1.5
Florida	928— 2.0	202— 0.7
Maryland	890— 1.9	369— 1.4
Virginia	785— 1.7	366— 1.4
Washington	537— 1.2	193— 0.7

During 1940-1961, the U.S. Alumni total increased at an average of 887 per year, making its *average an-*

[1] The U.S. center in 1940 was 2½ miles SE by E of Carlisle, Ind.; and in 1960 it was 6½ miles NW of Centralia, Ill.

nual percentage gain 3.3 per cent. Corresponding data given below for the regional areas indicate that all but the North Atlantic region exceeded the national average, and that the Western region exceeded it nearly threefold.

U.S. Total	*887—3.3%*	South Central	45—4.4%
Western	184—9.1%	North Central	125—3.8
South Atlantic	122—5.0	North Atlantic	411—2.2

Similar comparative data by the leading states show that all save three—Illinois, New York, and Massachusetts—and the District of Columbia equaled or exceeded the national average annual percentage gain of 3.3 per cent; while Florida and California grew, respectively, at rates over five and three times the national average.

Florida	35—17.1%	New Jersey	60— 4.6%
California	132—10.6	Pennsylvania	51— 3.7
Washington	16— 8.5	Ohio	32— 3.3
Michigan	35— 8.2	Illinois	21— 2.3
Maryland	25— 6.7	District of Columbia	16— 2.0
Texas	27— 6.4	New York	95— 2.0
Virginia	20— 5.5	Massachusetts	138— 1.6
Connecticut	48— 4.8		

☆ ☆ ☆

In the 1961 Register 3,841 Alumni (exclusive of those with APO and FPO addresses) are recorded as resident abroad in 103 foreign countries, while in the 1940 Register 1,728 Alumni were recorded as resident in 72 foreign countries. The data which follow show that Asia and North America, with 1,608 Alumni, now account for nearly 11 per cent *less* of the foreign total than in 1940, whereas Europe and South America, with 1,693 Alumni, now account for 13 per cent *more* than in 1940.

	1961	*1940*
Foreign Total	*3,841—100%*	*1,728—100%*
Europe	1,032— 26.9%	336— 19.4%
North America	878— 22.8	477— 27.6
Asia	730— 19.0	434— 25.1
South America	661— 17.2	200— 11.6
Oceania	184— 4.8	112— 6.5
West Indies	154— 4.0	97— 5.6
Africa	107— 2.8	33— 1.9
Central America	95— 2.5	39— 2.3

Similar comparative data by the leading foreign countries show that Canada, Mexico, Japan, and the Philippines now with 1,112 Alumni account for nearly 10 per cent *less* of the foreign total than in 1940, whereas India, France, Brazil, Venezuela, and Colombia now with 777 Alumni account for nearly 9 per cent *more* than in 1940.

	1961	*1940*
Canada	690— 18.0%	354— 20.5%
India	220— 5.7	63— 3.7
France	188— 4.9	48— 2.8
Mexico	188— 4.9	123— 7.1
United Kingdom	183— 4.8	96— 5.5
Brazil	141— 3.7	37— 2.1
Venezuela	133— 3.5	25— 1.4
Japan	119— 2.9	102— 5.9
Philippines	115— 2.8	85— 5.0
Norway	110— 2.9	38— 2.8
Argentina	98— 2.6	34— 2.0
Colombia	95— 2.5	25— 1.4

During 1940-1961, the total of foreign Alumni increased at an average of 101 per year, making its *average annual percentage gain* 5.7 per cent, while for South America, Africa, and Europe the average annual percentage gains were approximately twice that of the foreign total, as follows:

Foreign Total	*101— 5.7%*		
South America	22—11.0%	North America	19— 4.0%
Africa	4—10.7	Asia	14— 3.3
Europe	33— 9.9	Oceania	3— 3.1
Central America	3— 6.8	West Indies	3— 2.8

Similar comparative data by the leading foreign countries show that Venezuela, France, Brazil, Colombia, and India each grew during 1940-1961 at a rate more than double that of the average annual percentage gain of the foreign Alumni total.

Venezuela	5—20.6%	Argentina	3— 9.0%
France	7—13.9	Canada	16— 4.5
Brazil	5—13.4	United Kingdom	4— 4.3
Colombia	3—13.3	Mexico	3— 2.5
India	7—11.9	Philippines	1— 1.6
Norway	3— 9.0	Japan	1— 0.8

Drawn by Henry B. Kane, '24.

In the 1961 Register there are 422 "Smiths" compared to 296 in the 1940 Register. In both books the second and third names most frequently found are "Brown" and "Johnson," but the presumably prolific "Jones" family, while it moved upward from 11th place in 1940 as shown by the listing below, only reached a tie for 8th in 1961—thus still trailing "Miller," "Davis," "Williams," and "Anderson."

1961		*1940*	
1. Smith	422	1. Smith	296
2. Brown	264	2. Brown	188
3. Johnson	242	3. Johnson	143
4. Miller	190	4. Davis	128
5. Davis	161	5. Williams	116
6. Williams	155	6. Miller	112
7. Anderson	147	7. Taylor	101
8. Jones	138	8. Clark	100
9. White	138	9. Hall	100
10. Wilson	138	10. Wilson	94
11. Moore	133	11. Jones	89
12. Taylor	131	12. White	89
13. Thompson	117	13. Moore	85
14. Lee	107	14. Thompson	76
15. Clark	106	15. Baker	74
16. Martin	106	16. Anderson	71
17. Baker	103	17. Lee	46
18. Hall	100	18. Martin	42

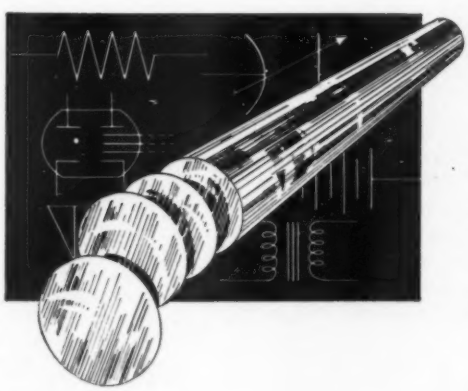
The 18 names recorded above as appearing at least 100 times in the 1961 Register account for a total of 2,898 Alumni, whereas in the 1940 Register there were

BUSINESS IN MOTION

To our Colleagues in American Business . . .

The special rod shown here, and the coin-like discs cut from it as shown in the sketch, are vital to the performance of electronic gear manufactured by a leading company. On these discs depends the fidelity of tone reproduction of the equipment.

Time was when the manufacturer had to maintain a staff of ten inspectors to keep tabs on these seemingly-minor parts. Today, he need use only two. Before, rejects ran as high as 40%. Now, rejection rate has dropped to a surprising low of but six pieces in 30,000!



Behind this story of savings — as in the case of so many others—you can find the Revere Technical Advisory Service at work. By combining the skills of the manufacturer's engineering department and Revere Methods and Production Departments, the reasons for the high rejection rate were discovered. In simplest terms, ordinary free cutting brass rod just couldn't do the job properly. Rigid control of molecular structure of the alloy — "kid glove" treatment at the rod mill — careful quality control all down the line — *all* played an important part. In this way, the Revere Technical Advisory Service, working closely with the manufacturer, was able to develop a rod that met the ultra-rigid specifications of the equipment.

Naturally, this is not an off-the-shelf item with a bargain price-tag. But this premium rod makes possible such great savings in per-unit cost that even the most exacting purchasing executives have been unable to work out a better way to handle the problem.

All of which leads to this point:

Whether you are buying metals, as here, or any other material, it is not always true economy to buy on a price basis. You will probably find that by taking your suppliers into your confidence—by discussing specific problems with them and adding their abilities and experience to your own—you will frequently cut costs in the long run or produce a superior product, or both.

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1,950 under these same 18 names. Three of the names —"Martin," "Lee," and "Anderson"—more than doubled during 1940-1961; and none totaled less in 1961 than in 1940 although the "Halls" neither gained nor lost, being 100 twenty-one years ago and 100 today.[2]

Geographically, nearly half of the 2,898 Alumni of these 18 names in 1961 appear on the rosters of the six leading states, viz.:

Total—"Smiths," "Browns," etc.			*2,898— 100%*
Massachusetts	540—18.6%	Pennsylvania	142— 4.9%
New York	287— 9.9	New Jersey	130— 4.5
California	226— 7.8	Connecticut	101— 3.5
Remaining in 42 states and foreign countries			1,472—50.8%

The 422 "Smiths" exactly match the total number of Alumni in the seven states of Idaho, Montana, Nevada, Utah, Wyoming, Alaska, and Arizona; the 264 "Browns" and the 242 "Johnsons" each total slightly less than the Alumni of the first six of these states. The 190 "Millers" are almost equal to the Alumni of Idaho, Montana, and Utah; and the 161 "Davises" are one more than the Alumni of Idaho, Montana, Nevada, and Wyoming.

There is now at least one "Smith" in 46 of the 50 states,[3] one "Brown" in 36, one "Johnson" in 35, one "Miller" in 31, and one "Davis" in 26. Each of the 18 names appears most frequently in Massachusetts, next in New York, and third in California—except that in California there are more "Johnsons," "Davises," "Lees," and *twice as many* "Joneses" as in New York.

☆ ☆ ☆

Of the 36,242 Alumni who responded to the 1961 Register query by verifying their addresses and other data, 28,884 (80 per cent) indicated the companies by which they were employed. Approximately five per cent of the 28,884 were with the following three companies:

1. General Electric Co.	593
2. American Telephone and Telegraph Co.	430[4]
3. E. I. du Pont de Nemours & Co.	413

Another five per cent were with the following seven companies:

4. Raytheon Co.	317
5. Radio Corporation of America	241
6. International Business Machines Corp.	237
7. Westinghouse Electric Corp.	203
8. General Dynamics Corp.	201
9. United Aircraft Corp.	191
10. Standard Oil Co. (N.J.)	170

A third five per cent, making 15 per cent, were with the 10 companies listed in the next column:

11. Sperry Rand Corp.	149
12. Boeing Airplane Co.	146
13. Sylvania Electric Products Co.	143
14. North American Aviation, Inc.	139
15. General Motors Corp.	138
16. Lockheed Aircraft Corp.	137
17. Eastman Kodak Co.	134
18. Arthur D. Little, Inc.	131
19. Bethlehem Steel Co.	126
20. Union Carbide Corp.	119

A fourth five per cent, making 20 per cent, were with the following 20 companies:

21. Hughes Aircraft Corp.	114
22. Martin Co.	99
23. Monsanto Chemical Co.	84
24. Minneapolis-Honeywell Regulator Co.	83
25. United States Steel Corp.	80
26. Avco Corp.	76
27. Shell Oil Co.	76
28. Bendix Corp.	75
29. Mitre Corp.	75
30. Socony Mobil Oil Co.	74
31. W. R. Grace & Co.	73
32. Stone & Webster Engineering Corp.	73
33. Texas Instruments, Inc.	72
34. Grumman Aircraft Engineering Co.	66
35. Procter & Gamble Co.	66
36. American Cyanamid Co.	65
37. Ford Motor Co.	61
38. Douglas Aircraft Corp.	59
39. Space Technology Laboratories, Inc.	58
40. Standard Oil Co. (Ind.)	54

A fifth five per cent, making 25 per cent, were with the following 42 companies:

41. Aero-Jet General Corp.	53
42. International Telephone & Telegraph Co.	50
43. Allied Chemical Corp.	49
44. Hercules Powder Co.	49
45. Northrop Corp.	47
46. Olin Matheson Chemical Corp.	46
47. Polaroid Corp.	46
48. United Shoe Machinery Corp.	45
49. Thompson-Ramo-Wooldridge, Inc.	44
50. Aluminum Co. of America	43
51. Dow Chemical Co.	43
52. Goodyear Tire & Rubber Co.	42
53. B. F. Goodrich Co.	42
54. Jackson & Moreland, Inc.	40
55. Philco Corp.	39
56. United States Rubber Co.	39
57. California Research Corp.	37
58. Humble Oil and Refining Co.	37
59. Merck and Co.	35
60. Standard Oil Co. (Calif.)	35
61. Foxboro Co.	34
62. General Radio Co.	34
63. Texas Co.	33
64. Charles T. Main, Inc.	32
65. Public Service Electric and Gas Co. (N.J.)	32
66. Allied Research Associates, Inc.	31
67. Chrysler Corp.	31
68. Consolidated Edison Co. of N.Y.	31
69. Corning Glass Works	31
70. Sprague Electric Co.	31
71. Laboratory for Electronics, Inc.	30
72. Republic Aviation Corp.	30
73. Rohm and Haas Co.	30
74. Allis-Chalmers Manufacturing Co.	29
75. Chance Vought Corp.	29
76. Boston Edison Co.	28
77. Combustion Engineering, Inc.	28
78. Edgerton, Germeshausen & Grier	28
79. General Foods Corp.	28
80. M. W. Kellogg Co.	28
81. McDonnell Aircraft Corp.	27
82. Newport News Shipbuilding and Dry Dock Co.	27

[2] The "Halls" continued to keep ahead of the "Q's" who numbered 39 in 1940 ("Quadri" to "Quiros") and increased to 86 in 1961 ("Quackenboss" to "Quynn"). By 1961, however, the "Q's" were no longer the least common name initial having been displaced by two "X's" ("Xavier" and "Xylas").

[3] In all but Idaho, Montana, and the two Dakotas. Incidentally, no one of the 16 Alumni in South Dakota, which is the smallest state Alumni-wise, bears one of the 18 names which appear 100 or more times in the 1961 Register.

[4] Includes: Bell Telephone Laboratories, 187; Bell System, 174; and Western Electric Co., 69.

1 2 3 4 5 6 7 8 9 count to 10

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   Indicated on mirrored anti-parallax scale.
3. **Sealed plug-in meter unit**
   Dustproof. No special shipping case required.
4. **Two pilot lights**
   Indicate both heating and cooling.
5. **Compact size: 6¼" H x 7½" W**
   Mount more in less space.
6. **Provisions for optional wiring in every instrument**
   For 120, 240 or 208 volts — 50 or 60 cy. Wired from the front.
7. **Interchangeable control modes**
   Change chassis for off-on, proportioning, etc., control.
8. **Thermocouple break protection**
   In every instrument at no extra charge. Shuts off heat if thermocouple breaks or burns out.
9. **Protected temperature setting knob**
   Guarded against accidental movement.
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    Complete instrument plug-in or explosion housings available.

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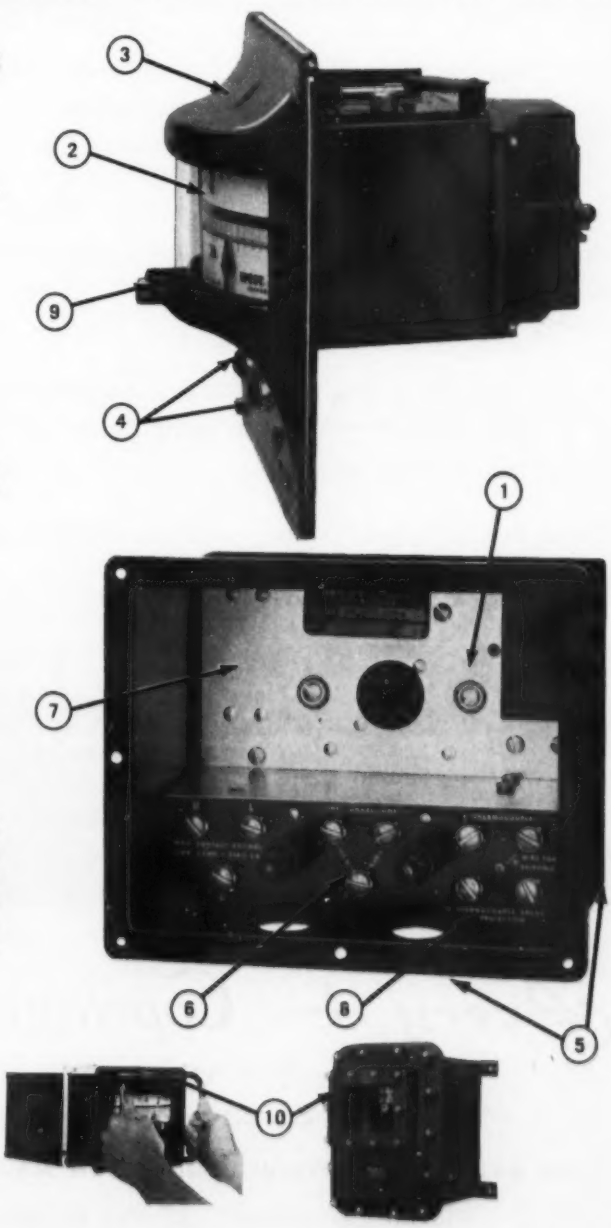

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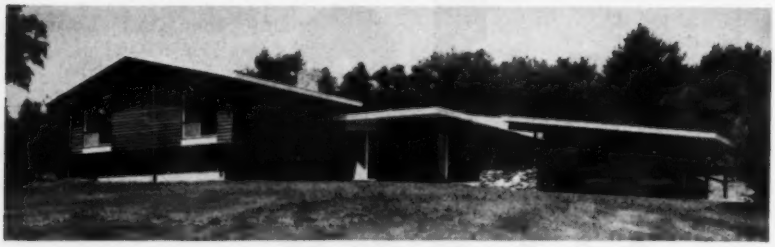

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Individuals Noteworthy

(Continued from page 10)

New Posts

NAMED in the news recently were the Alumni whose elections, promotions, and appointments follow:

C. Lalor Burdick, '13, as a Director, Planned Parenthood Federation of America . . . *Paul J. Cardinal, '24,* as Treasurer, Drug, Chemical and Allied Trades Association, Inc. . . . *F. Marcucella, '27,* as President, John A. Volpe Construction Company, Melrose, Mass.;

William E. Shenk, '28, as a Vice-president, Abbey Etna Machine Company, Perrysburg, Ohio . . . *Ira H. Abbott, '29,* as Director, Office of Advanced Research and Technology, National Aeronautics and Space Administration . . . *Salvador Madero, Jr., '29,* as Executive Vice-president, Cia. H. K. Porter Company de México, S.A.;

Thomas A. Fearnside, '31, as a Director, Stone & Webster Engineering Corporation . . . *Eugene P. Worthen, '32,* as Assistant Technical Manager, Shipbuilding Division, Bethlehem Steel Company . . . *Arthur W. Gilbart, '35,* as a Vice-president, Freeport Sulphur Company;

Benjamin F. Schlimme, Jr., '35, as Assistant General Manager, Industrial and Biochemicals Department, E. I. du Pont de Nemours and Company . . . *John F. Snuggs, '38,* as Chief Engineer, General Engineering Department, American Oil Company;

Richard E. Whiffen, '44, as General Manager, Bendix Products—Aircraft Division . . . *Lloyd H. Turoff, '45,* as Secretary, Rhode Island State Board of Registration and Examination of Architects . . . *Kenneth L. Block, '47,* as a Director, Littelfuse, Inc., Des Plaines, Ill.;

Martin W. Essigmann, '47, named Dean of Research, Northeastern University . . . *Richard W. Warren, '49,* as Manager of Sales for Germany, Holland, and Italy, Chicago Bridge & Iron Company . . . *John F. Jacobs, '52,* as Assistant Vice-president—Technical Operations, The Mitre Corporation . . . *George B. Raymond, '55,* as a Director, Raymond Engineering Laboratory, Inc., Middletown, Conn.

(Continued on page 40)

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By earnings?

The 1960 average earnings of Massachusetts Mutual full-time representatives with five or more years experience was $13,505.

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Frederic F. Lawall, '22, New York
David K. Aldrich, C.L.U., '38, Allentown
Frank W. Hiller, '43, Home Office
Richard A. Faust, '56, Binghamton
Aman M. Barber, Jr., '59, Allentown

LEHIGH

Russell E. Hoaster, C.L.U., '31, San Antonio
Edward Billstein, Jr., '40, Atlanta
R. Lester Dodson, Jr., '44, New York

M. I. T.

Lyman L. Tremaine, C.L.U., '23, New York
Harold Goodheim, '39, San Francisco
Harold G. Ingraham, Jr., '49, Home Office

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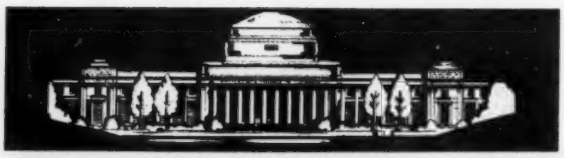

The Laboratory's staff of over 1000 under the direction of Dr. C. Stark Draper is engaged in the conception and perfection of completely automatic control systems for the flight and guidance of missiles and space vehicles. Its achievements include the Navy Mark 14 Gunsight, the Air Force A-1 Gunsight, Hermetic Integrating Gyros (HIG), and the Ship Inertial Navigation System (SINS). The Laboratory developed basic theory, components and systems for the Air Force THOR and, later, the TITAN missile. Other accomplishments include the Navy's POLARIS Guidance System.

Recently, the Instrumentation Laboratory was selected by NASA to develop the guidance navigation system for the moon space craft project, APOLLO.

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Individuals Noteworthy

(Continued from page 38)

At M.I.T. Now

RECENT appointments to the Institute's staff include those of *Peter D. Leavitt* as assistant director of admissions and *Jerome H. Adler* as supervisor of Audio-Visual Services.

Mr. Leavitt, a graduate of Union College, in Barbourville, Ky., has been assistant director of admissions at Babson Institute, done marketing research for the Liberty Mutual Insurance Company, and served for two years aboard a cutter with the U.S. Coast Guard.

Mr. Adler, a graduate of the Central Technical Institute in Kansas City, has had wide experience as an engineer in tape recording and communications work.

Dr. Bolt's New Post

THE National Science Foundation has established a Science Resources Planning Office and named Professor Richard H. Bolt, who is on leave from M.I.T., to head it.

"The word 'resources' in the name of the Office," says Dr. Bolt, "means the scientists and engineers who teach and do research, their equipment and publications, the facilities and institutions in which they work, and the dollars they spend. It also covers the products of science—new knowledge and new trained personnel—for these are in turn resources for more science, for technology, and for all science-based endeavor."

Aerospace Leaders

PROFESSOR H. Guyford Stever of M.I.T., who is president of the Institute of the Aerospace Sciences, will be the toastmaster at an IAS dinner on December 5 in Orlando, Fla., and the guest of honor and principal speaker will be Major General *Leighton I. Davis, '41,* USAF, Commander of the Patrick Air Force Base Missile Test Center.

Captain *Thomas J. Rudden, Jr., '46,* Deputy to Admiral Raborn, Chief of the Bureau of Naval Weapons, will speak at an IAS luncheon the preceding day; and *George C. Pfaff, Jr., '39,* will be a co-chairman of a session concerned with aircraft support.

(Concluded on page 42)

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TECH NEWS

FOR SCIENTISTS, MATHEMATICIANS
OPERATIONS EVALUATION GROUP, M.I.T.

In its research and analysis for the Chief of Naval Operations and Fleet Commanders, the Operations Evaluation Group, M.I.T., pursues knowledge in virtually every sphere of naval interest.

Consider OEG study 644, for example, entitled "Echo Variability and the Formulation of a Radar Theory." OEG's analysts found that blaming radar operators and poor radar maintenance for variability of signal presentation on radar scopes (all other things supposedly being equal) was convenient but erroneous. New culprits will have to be isolated and bested. OEG thinks it has found some of them for the Navy.

When is a sea not a sea? When it's a swell. Seriously. Seas and swells, ramp-to-touchdown distances, vertical velocities, wave-to-wave amplitude variations, and similarly specialized factors enter into "The Effect of Ship Motion and Flight Deck Geometry upon Carrier Air Operations." This is Naval Warfare Analysis Group Study No. 20 (NAVWAG being the long-range studies division of OEG). One interesting conclusion: Position of the touchdown point has a greater effect on precluded flying time than does ship length. And on the subject of ship length, the minimum recommended (for an angled-deck carrier) is 800 feet.

Would you like to have a hand in similar research, knowing that you would be contributing importantly to the national defense? Well paid career appointments in Washington, D.C., and Cambridge are available to scientists, mathematicians and engineers with advanced degrees. Direct your inquiry to the Director, Dr. Jacinto Steinhardt, either in Washington or in Cambridge.

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Individuals Noteworthy

(Concluded from page 40)

In Operations Evaluation

THE Economics Division of the Operations Evaluation Group, M.I.T., is to be expanded under the supervision of *Stephen Enke* of Duke University. This division is concerned with problems of logistics, weapon systems evaluation, and Navy support requirements. Dr. Enke was for 10 years chief of the Rand Corporation's logistics department and has been a visiting professor of economics at Yale University.

Recent additions to the OEG research staff announced by its Director, Jacinto Steinhardt, include: *Marc A. Nerenstone,* ceramics engineer; *Vernon E. Palmour,* operations analyst; *Bruce F. Powers,* physical chemist; and *Howard L. Wiener,* mathematician.

Stephen Enke

50 Years at M.I.T.

ABNER STODDER completed a half century of continuous employment as an electrician at M.I.T. on October 26, and was honored by many of his colleagues at a reception in Kresge Auditorium.

He started in the Instrument Room of the Electrical Engineering Department when the Institute was located at Copley Square, completed a two-year night course at Wentworth Institute in 1914, and became an electrician in the Physical Plant Department when M.I.T. moved to Cambridge in 1916. He has never been late for work and has never missed the commencement exercises—a record for which he has been acclaimed in the Boston newspapers.

Mr. Stodder was the first president of the M.I.T. Quarter Century Club, is a 32d degree Mason, and has long been active in civic affairs. His wife, Mrs. Helen Stodder, is a nurse in the M.I.T. Infirmary.

Ab Stodder (at left) and Vice-president Philip A. Stoddard, '40, examining a picture of the room where Mr. Stodder began work for M.I.T. in Boston.

Moment of Truth . . .

Remember? The bluebooks were passed, the exam questions posted . . . then the panicky moment of blankness before facts gradually swam into focus. Final exams were the crucible of study and, in a real sense, forerunners of the many "moments of truth" for which each of us must prepare throughout life.

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Astronautics projects include booster systems and manned/unmanned space vehicles plus extensive activities in broad fields of research and development. Engineers and scientists who qualify will be given key responsibilities in these fields . . .

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Trend of Affairs

(Continued from page 16)

Lecturers on Electronics

LINCOLN LABORATORY began presenting a series of lectures on "The Age of Electronics" last month to observe its 10th anniversary. These lectures are being given in the evening, at 8:00 P.M., in Kresge Auditorium, and the dates, topics, and speakers include:

December 11—"Communications," by Lloyd V. Berkner, the President of the Graduate Research Center of the Southwest, in Dallas, and chairman of the Space Science Board of the National Academy of Sciences;

January 9—"Computers," by Stanislaw M. Ulam, a research adviser of the Los Alamos Scientific Laboratory, who is noted for initiating the widely used Monte Carlo method for the statistical treatment of mathematical problems too complex for conventional analysis;

January 16—"Radio Telescopes," by Edward G. Bowen, chief of the Division of Radio Physics in the Commonwealth Scientific Industrial Research Organization in Sydney, Australia, and an original member in 1935 of the English radar development team;

January 23—"Transistors," by William Shockley, '36, co-winner of a Nobel prize for fundamental contributions to transistor physics and now Director of the Shockley Transistor Unit of Clevite Transistor, in Palo Alto, Calif.;

February 6—"Masers," by Charles H. Townes, Provost of M.I.T., and holder of the fundamental patent on these revolutionary low-noise amplifying devices;

February 27—"Satellite Relays," by John R. Pierce, in whose division at the Bell Telephone Laboratories the work on Project Echo was done.

The first two speakers in this lecture series were to be Hendrik B. G. Casimir, discussing "Maxwell, Hertz, and Lorentz," and Ivan A. Getting, '33, on the subject of "Radar." Dr. Casimir is the director of the renowned Philips Research Laboratories, and Dr. Getting, a former professor at M.I.T., is president of the Aerospace Corporation in El Segundo, Calif.

Microfilm System Research

THE Council on Library Resources, Inc., has granted $27,070 for construction of a model of a relatively inexpensive microfilm finder-reader system for library use, under the supervision of Peter R. Scott, Head of the Microreproduction Laboratory of M.I.T. Libraries.

The objective is to eliminate an inherent weakness in roll microfilm systems—the reader's inability to search through a long roll for the material he is seeking without wasting a lot of time. This has been a major deterrent to the use of roll microfilm. A mechanism is planned now that will be equipped with a stroboscopic finding device to enable the reader to observe an index continuously while the film is in rapid motion.

The project resulted from two years' preparatory research, and the grant provides for construction of a system compatible with the general design of existing, commercially available microfilm readers. The work will be done jointly by the Microreproduction Laboratory and Edgerton, Germeshausen & Grier, Inc.

(Concluded on page 46)

SUBJECT: PERSONAL SERVICE

FLETCHER CHAMBERLIN AND OLNEY MORRILL TALK ABOUT PERSON-TO-PERSON SERVICE AND WHAT IT MEANS FOR THE CUSTOMERS OF THE

NEW ENGLAND MERCHANTS NATIONAL BANK

(Mr. Morrill is a Senior Vice President and Mr. Chamberlin is a Vice President of the newly formed New England Merchants.)

MORRILL: You know, I've been in banking a long time, but I'll never lose the satisfaction I get when someone says: "Will you help me with my banking problems?"

CHAMBERLIN: Well, that's the kind of question that leads to the person-to-person service we emphasize.

MORRILL: Right. And we welcome the responsibility which goes along with it.

CHAMBERLIN: That's exactly the way I think of it, because we always took this responsibility very seriously at The New England Trust before our consolidation, the same way you did.

MORRILL: One thing: it isn't a general or group responsibility either—but a *personal* responsibility for each customer and his needs. Not always an easy job, but it is a vital one.

CHAMBERLIN: And a sense of responsibility like this seems to translate itself naturally into the person-to-person service the new New England Merchants offers every customer . . .

MORRILL: Whether his business is in our commercial or trust department or anywhere else in our Bank.

CHAMBERLIN: When you come right down to it, the basis for our personal service is really very simple. We try to put ourselves in our customers' shoes—that way, we gain a better insight into their needs.

MORRILL: And that's how we arrived at many of our services: having banking windows open ten hours a day, a new motor bank, an investment plan for those with $5,000 or more to invest—just to name a few.

CHAMBERLIN: Sounds like a pretty good bank to do business with, doesn't it?

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Trend of Affairs

(Concluded from page 44)

The Alumni Council Meets

AT ITS first fall meeting, with D. Reid Weedon, Jr., '41, presiding, the M.I.T. Alumni Council heard Professor Hans Mueller discuss teaching and Dr. Samuel D. Clark explain the work of the Institute's medical staff.

Professor Mueller stressed the importance of making undergraduates want to learn and demonstrated with his voice and gestures how he creates tension and suspense in his classroom. No one who has written a textbook should be allowed to lecture, he said, and no one should give the same course for more than four years.

Dr. Clark described the Faculty Health Survey begun 10 years ago and the student and employee health programs. Each student who enters M.I.T. now brings a report from his family physician, examinations are given by appointment, and the queues that many Alumni recall are gone. Very few young people have been denied admission to the Institute because of health problems.

Russell W. Ambach, '24, presented resolutions occasioned by the death of Francis A. Barrett, '24.

H. B. Kane, '24, reported that last year's Alumni Fund of $575,596 was second only to the 1960 Fund. Hugh S. Ferguson, '23, reporting for the Audit and Budget Committee, announced that The Technology Review had returned a profit to the Alumni Association and that the salary of its publisher, H. E. Lobdell, '17, which was $1 a year, had been quadrupled.

On the Textile Frontier

SIGNIFICANT breakthroughs on problems of surface mechanics, as contrasted with those of internal mechanical properties, of fibers, yarns, and fabric structures were forecast by Milton M. Platt, '42, when he accepted an award for distinguished achievement from The Fiber Society this fall. Dr. Platt is vice-president and associate director of Fabric Research Laboratories, Inc., in Dedham, Mass.

"Although much work has been done in this field," he said, "it is understandable why most of the approaches thus far have been chiefly exploratory and semi-empirical, for the problems of surface mechanics are indeed very complex. A better understanding of the how and why of the mechanical interaction of fibers in finished fabrics will give insight to many problems plaguing the textile industry today." Many of these problems, he believes, may be resolved by a better understanding of surface forces, resistance to motion, and the mechanical response of surfaces and stress-transmission among the fibers comprising a textile product.

College Publications Seminar

THE M.I.T. Office of Publications was host this fall to an all-day seminar on designing publications for educational institutions. Representatives of many New England schools and some institutions as distant as the Illinois Institute of Technology, Iowa State University, and Stanford University attended. John I. Mattill, Director of Publications at the Institute, presided and the discussion dealt largely with work done by Jacqueline Casey, Muriel Cooper, Ralph Coburn, '47, and others for M.I.T.

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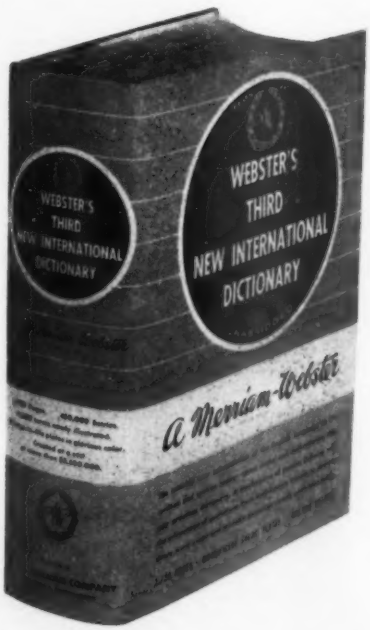

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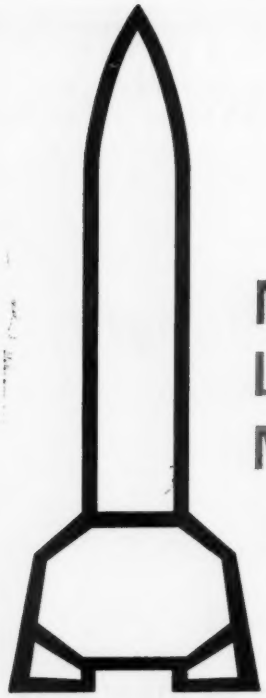

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For information on the pattern recognition position write or phone direct to Dr. Taffee Tanimoto, Head of Pattern Recognition Laboratory.

Further information on the programming positions is available through Mr. Joseph Van Horn, Head, Computer Laboratory.

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Krakatau Revisited

(Concluded from page 23)

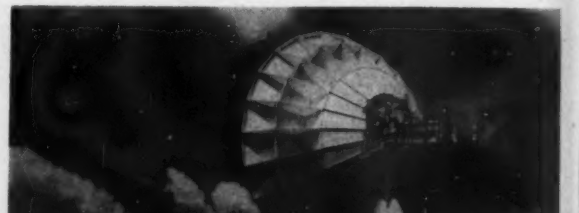
The energy in the larger individual eruptions approximated the energy released in detonating 170 tons of TNT; about the energy of a small nuclear bomb. Much of this was dissipated, however, in nonexplosive heat. The actual explosive energies generating the small ground shock waves recorded by the seismograph were about those associated with detonating 15 tons of TNT. The daily energy release was much more impressive, totaling that of 31,000 tons of TNT (3.1×10^{13} calories)!

A little was learned about the mechanism of Anak Krakatau's recent eruptions, but as always more new problems were posed than answered. Where is the ultimate source of volcanic heat? If it is not caused by small anomalous hot spots of natural radioactive decay (volcanic rocks are often low in uranium, thorium, and potassium content), by what means is pressure reduced at a depth to allow the normally hot but solid mantle of the earth to partially melt? How does the molten rock come to the surface, and why in such diverse ways at such irregular intervals? To seek a good answer was one purpose of the expedition. Estimating the present danger of Krakatau requires an understanding of these problems.

Nature has unleashed volcanoes on the world throughout geologic time. Man has just begun to fight back.

REFERENCES: Decker, R. W., and Hadikusumo, D., 1961, Results of Jan. 1960 Expedition to Krakatau: *Jour. Geophys. Research*, in press; Neumann van Padang, M., 1951, Catalogue of Active Volcanoes of the World Including Solfatara Fields: Part 1, Indonesia, International Volcanological Assoc., Napoli, Italy; Royal Society, 1888, The Eruption of Krakatoa: Trübner & Co., London, 494 p.; Stehn, Ch. E., 1929, The Geology and Volcanism of the Krakatau Group: *Proc. 4th Pac. Sci. Congr.*, Batavia; Van Bemmelen, R. W., 1949, The Geology of Indonesia: Martinus Nijhoff, The Hague, Volume 1, pp. 188-256; Verbeek, R. D. M., 1886, Krakatau, Batavia; Williams, Howell, 1941, Calderas and Their Origin: Univ. of Cal. publications, *Bull. Dept. Geol. Sci.*, Volume 25, No. 6, pp. 239-346.

In The Review Next Month



LINCOLN LABORATORY will be featured in text and photos in the January, 1962, issue of The Review. Pictured here is the radar it operates on Millstone Hill in Westford, Mass.

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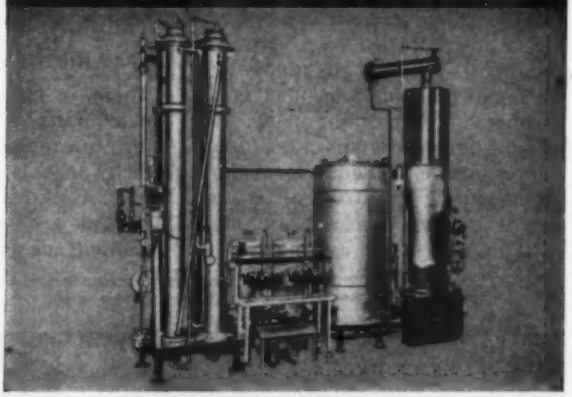

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Instrumentation Developments

(Concluded from page 26)

How does one find information on methodology and instrumentation? Strangely enough, at present, by chance only. Every research worker becomes familiar, during his study or his work, with a number of methods which he uses later on, but whether these are optimal methods for a given purpose usually remains unknown. In many cases, too, the question whether a suitable method or instrument already exists and is described in the literature, or must be developed, remains unanswered.

The remedy for this lack of information is twofold: Integration of the field of instrumentation, and better instrumentation education. Instrumentation, in order to be of value, must be treated on a very general level. The methods used in one field can be applied in other fields, methods of measuring light scattered from protein molecules, for example, are not different from those of measuring light from a star, and signal-to-noise problems are identical in biology and astronomy.

We, in the group at M.I.T. with which I am connected, have taken up the problem of integration of the entire field of instrumentation. The available wealth of material has been made manageable, in our opinion, by the breakdown of all instruments into their basic units, their building blocks, which we call instrumentation elements. There is a finite number of elements from which the infinite number of complete systems can be composed or synthesized. A logical grouping of these elements assures us reasonably complete coverage and elimination of redundancy. With the help of this system we hope not only to establish a logical coding system for information retrieval for all instruments, but also a system that can be used in teaching instrumentation.

The Virtues Required

There is little doubt that in the near future new general courses in instrumentation will be offered in many schools and universities. Nobody working in the experimental natural sciences can afford to be without adequate knowledge of instrumentation; it not only furnishes the practical tools for scientific accomplishment, but also, like mathematics, can profoundly influence the direction of one's research and increase one's research potential.

We are living in a scientific world of ever-increasing specialization and of ever-increasing isolation of the single research worker. This sometimes gives us status as individuals —yet we regret it, because it leads to a breakdown of communications between the sciences. Intellectual values that result from familiarity with our neighbor's way of thinking are often lost, and science—which aspires, ultimately, for unification and integration—is imperiled by the very specialization it has developed.

Because of instrumentation's interdisciplinary character, it can be the common ground between many scientific disciplines. It can provide that common language which assures useful communication and understanding between individual fields, provided we succeed in endowing it with the virtues every science should strive for: basic understanding, simplicity, and logic.

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Thought and Language

LEV SEMENOVICH VYGOTSKY

The *magnum opus* of an influential Soviet psychologist finally available in translation. Vygotsky's major contributions were his theory of concept formation and development of the other specifically human intellectual functions, and his experimental method of "double stimulation." With introduction by Jerome S. Bruner and appended comment by Jean Piaget.

Technological Progress in the Petroleum Refining Industry:

A History of Process Innovation

JOHN L. ENOS

The history, with economic analysis, of innovations in petroleum cracking in America since 1913, describing the advances, their environment, and the men responsible for their adoption. The author attempts to measure the accrued value of this progress and shows how the profits were divided among inventors, companies, and consumers.

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Books

Historic Papers on Economics

HAVE you ever read William Jennings Bryan's *Cross of Gold* speech? Alexander Hamilton's *Report on Manufactures?* Calvin Coolidge's veto of agricultural price supports? These and other such documents are now available in a paperback book, *American Economic Policy Since 1789,* edited by William Letwin, Associate Professor of Industrial History at M.I.T. (Doubleday Anchor, $1.45).

In his introductory essay, Professor Letwin discusses the forces and movements that helped to make American economic policy "exceedingly confused." Great debates, he thinks, make great and classic documents, and he has selected 29 of them for this volume.

Have You Seen These?

RECENT BOOKS likely to be of especial interest to M.I.T. Alumni include:

Field Theory Handbook, including co-ordinate systems differential equations and their solutions, by Professor Parry H. Moon, '27, of M.I.T. and Professor Domina Eberle Spencer, '39, of the University of Connecticut (Springer-Verlag, 1961, $17.25).

From Theory to Practice in Soil Mechanics, selections from the writings of Karl Terzaghi, formerly professor in the M.I.T. Department of Civil Engineering; with a bibliography and contributions on his life and achievements prepared by L. Bjerrum, A. Casagrande, R. B. Peck, and A. W. Skempton, including accounts of his activities at M.I.T. as well as in many other parts of the world (John Wiley & Sons, 1960, $12).

Shock and Vibration Handbook Library, edited by Cyril M. Harris, '45, and Charles E. Crede, '36 (McGraw-Hill Handbook Series, 1961; three volumes, $47.50).

In the Periodicals

PROFESSOR Philip M. Morse and George F. Koster, '48, Associate Professor of Physics, contributed the leading article, entitled "Graduate Record vs. Achievements," to the August, 1961, issue of *Physics Today.* It dealt statistically with the records and accomplishments of doctoral Alumni in physics since 1931. . . . Professor Roland B. Greeley contributed the leading article, entitled "A City Planner Looks at the Urban Explosion," to the July, 1961, issue of the *Journal of the Boston Society of Civil Engineers.* In the same issue, David D. Jacobus, '30, described the survey made for the Cambridge Electron Accelerator. . . . L. F. Hickernell, '22, described "Cable Engineering, A Multidiscipline Technology," in the October, 1961, issue of *Electrical Engineering.* . . . Professor M. S. Livingston and W. A. Shurcliff described "The Cambridge Electron Accelerator" in the October 20, 1961, issue of *Science.* . . . The Lester Gardner Lecture on "Early Blind Flying," by J. H. Doolittle, '24, was featured in the October, 1961, issue of *Aerospace Engineering.*

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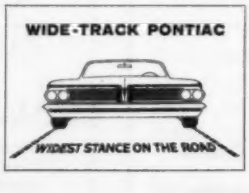

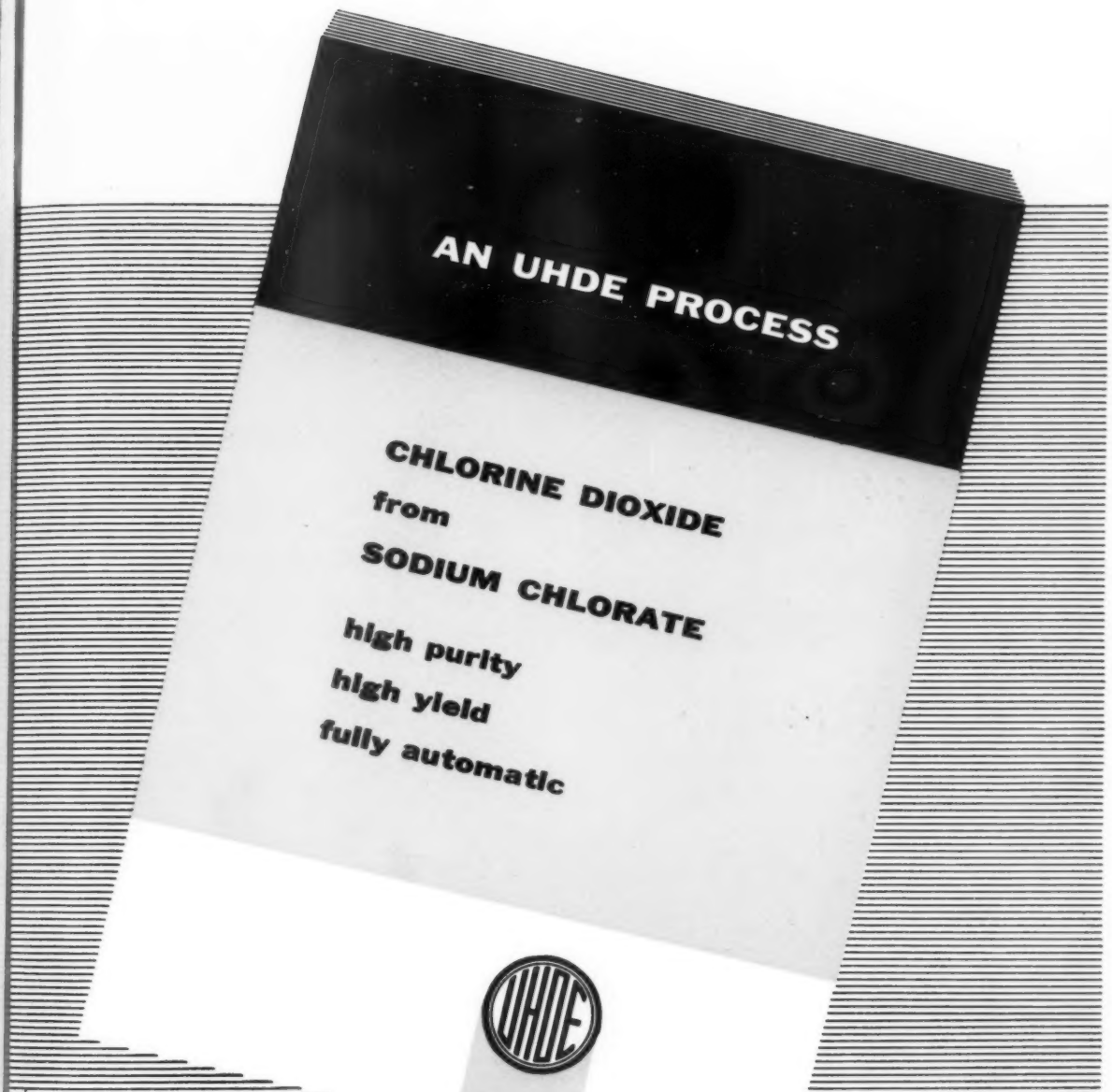

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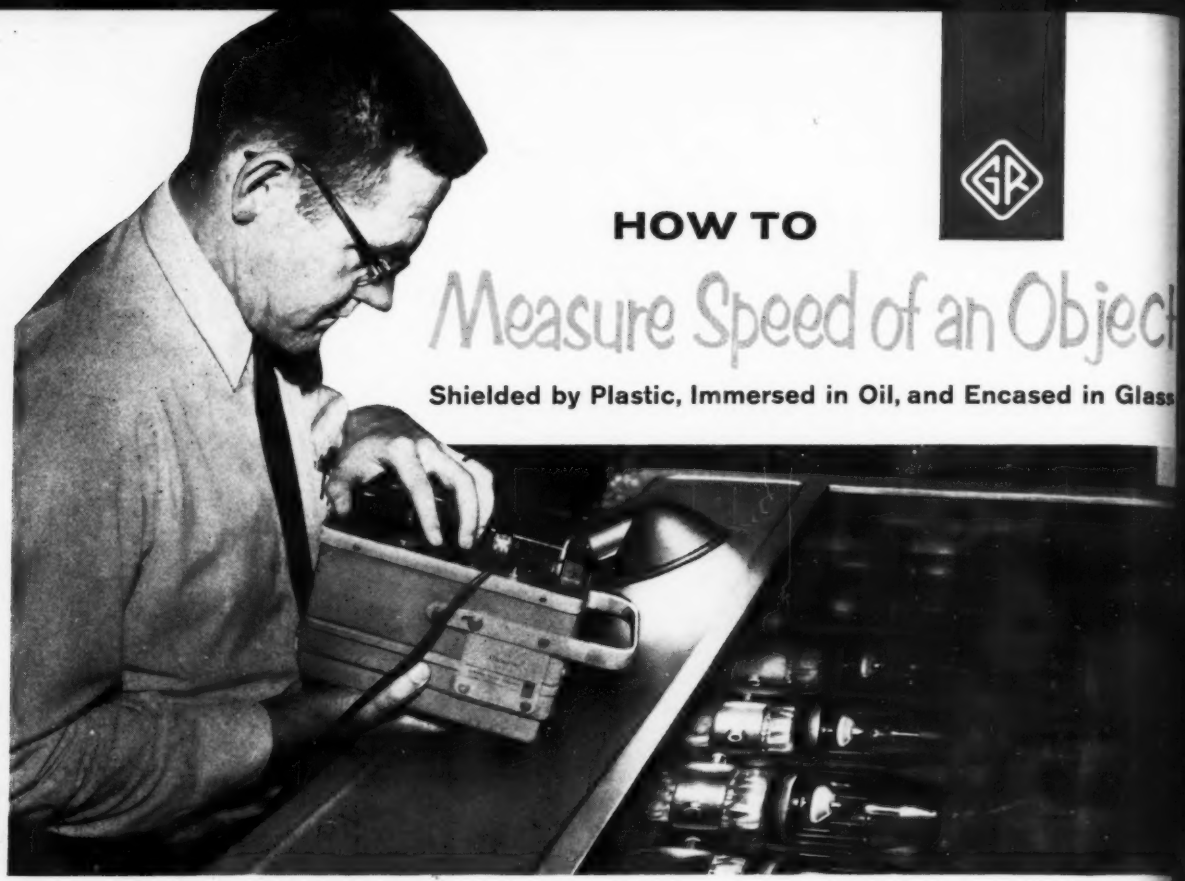

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